OCTOBER 26, 1961

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY

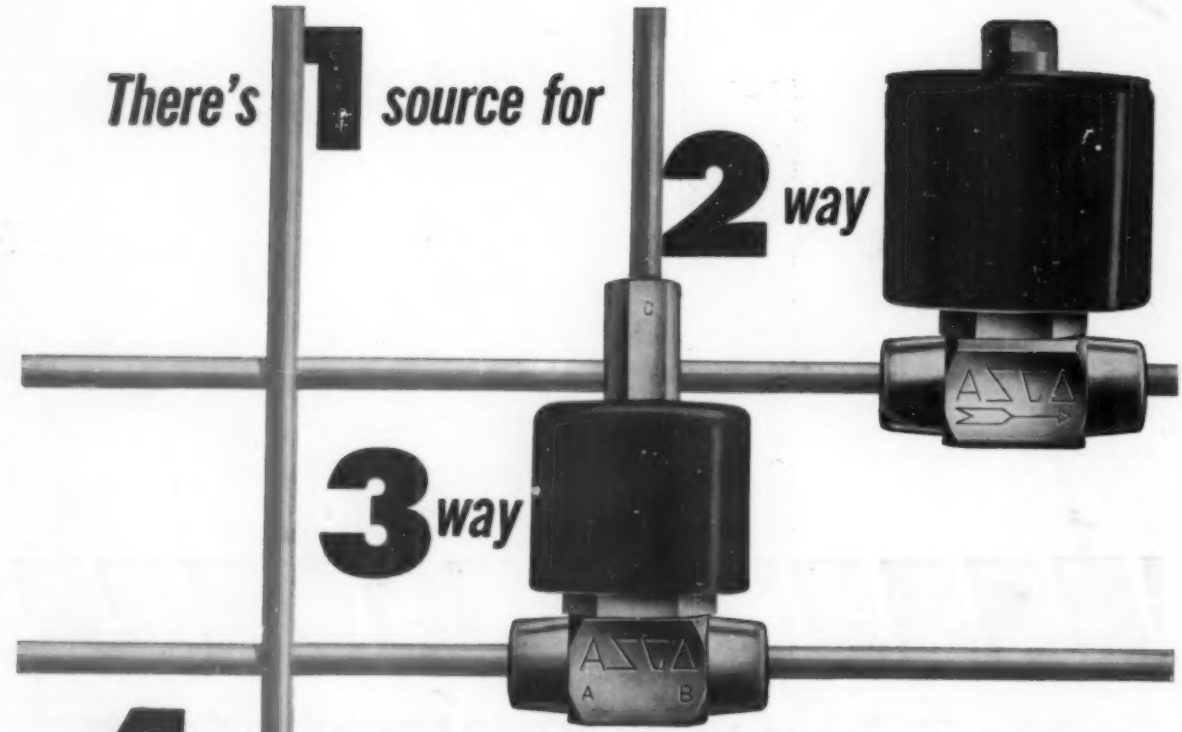
Learning to live with a COMPUTER

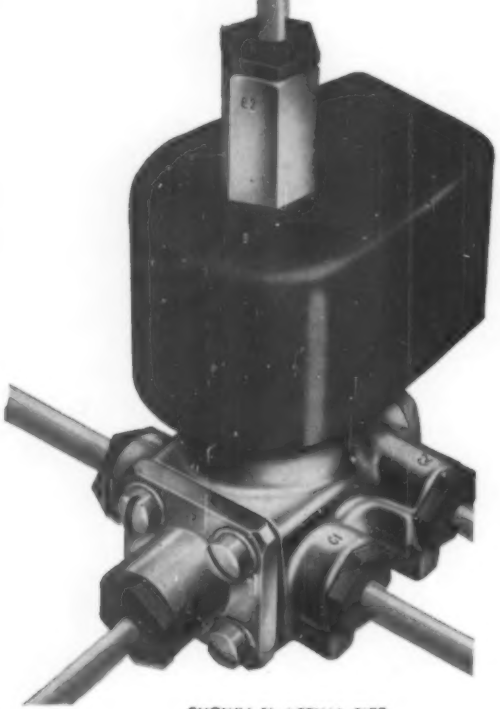
Contents, Page 3

MR. STEVENS RICE
UNIVERSITY MICROFILMS
313 N. FIRST ST.
ANN ARBOR, MICH.

```
        GO TO 22 IF J1R0
        G17=G17+D17*X12
   22   D17=D17+D13
        D9=D14+D15+D16
        GO TO 36 IF J1R0
        XJ1=G16+G17+G18
        X13=J1
        GO TO 61 IF Z3R14.
        AT$     $ T$F 63$
        TH0 TZ0 TD9 TXJ1 TD14 TD15 TD16
        TD11 TD12 TD13 TX13
   61   GO TO I11
   10   GO TO 3 IF Z1V0.
        H13=-.5*G(2,J4)
        H12=-H13*X14
        X1=0.MX2=0
        GO TO 5 IF
        D8=0. MH(2
    5   GO TO 11 I
        AT$     $ T
        TJ4 TG(3,J4
        TG(1,J4) TG
   11   GO TO I14
    3   H1
        Z4=Z1/X14
                                  )/Z4-Z4)
        I11=4 MH0=H12 MZ0=Z4
        GO TO 30
        I1 =6 MH0=H13 MZ0=Z1
        GO TO 30
    6   X4=D9/(Y4*X16)
        X15=X4-X3
        G
        GO TO 5 IF D8U1.
        I
        GO TO 65
        X1
        I12=8 MH11=H13 MZ10=Z1
        GO TO 65
    8   X2=C0/(Y4*X16)
        X1=M1+X2
        Y1*X
        J4)=
        D8=X19*(Y5*.5*G(2,J4)+X18)*X16
        D8=D8/(1
        G(3,J4)=
        GO TO 5
   95   GO TO 90 IF X0U0.
        GO TO 96 IF X0V0.
        K7=-1. MX0=-X0
        GO TO 97
   90   D6=1.
        GO TO I10
   96   K7=1
   97   GO TO 99 IF X0W2.5
        X5=D5*X0
        X6=X5 MX7=X0*X0 MI1=1 MI2=0
        100,K8,1,1,200,
        X8=I1
        I1=I1+2
        X9=I1
        I2=I2+1
        X10=I2
        X6=-X6*X7*X8/(X10*X9)
        X5=X5+X6
```

There's 1 source for 2 way 3 way or 4 way MIDGET SOLENOID VALVES





SHOWN ¾ ACTUAL SIZE

Progressive designers, the men who lead the trend toward miniaturization, depend on ASCO as the one source for a full line of midget solenoid valves. The unexcelled quality and dependability that ASCO pioneered in the solenoid valve field is found, too, in today's midget solenoid valves. Only the size has been reduced.

For flow applications using air, gas, water, light oil, refrigerants and many other liquids, ASCO Midget Valves assure complete safety and truly exceptional performance.

ASCO Midget Solenoid Valves are available with standard, watertight or explosion-proof enclosures. Pipe sizes ⅛" and ¼"; pressure range 0-1000 psi.

There's *one* source that solves virtually any solenoid valve problem — ASCO. Write today for complete data on ASCO Midget Solenoid Valves — or outline any of your requirements. We'll be pleased to assist you.

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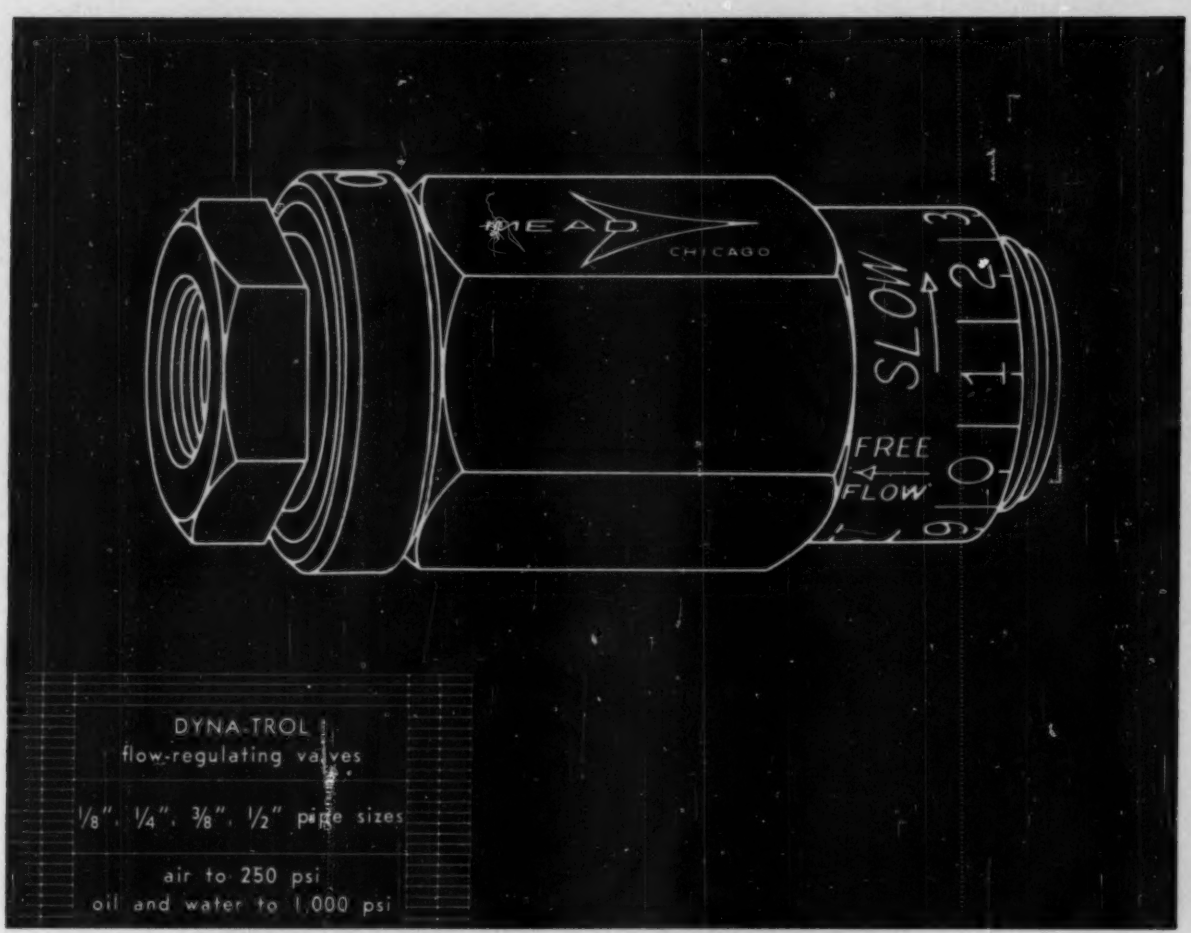
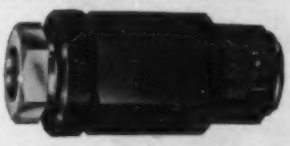
Circle 201 on Page 19



PROBLEM: how to replace a 1/4" valve with a less-costly 1/8" valve (and get extra precision in low-flow ranges)

SOLUTION: NEW MEAD DYNA-TROL VALVE



Check these design advantages of the new MEAD DYNA-TROL flow-regulating valve:

- Adjusting sleeve — easily rotated by hand — locks to any setting and cannot be accidentally removed from valve body
- Calibrated sleeve records settings for future reference
- Knife-edge variable orifice reduces flow distortion caused by viscosity changes in working medium
- No internal springs to cause malfunction
- All parts rust-proof
- Wide operating range: −40° F. to +250° F.

Small, economical MEAD DYNA-TROL flow-regulating valves can replace more costly valves of larger pipe size. Reason: Internal design permits pneumatic or hydraulic flow equal to full pipe area in both directions. The first 360° turn of the adjusting sleeve increases flow from zero to about 10% of potential — a new measure of precision in low-flow ranges. Successive turns accurately reach 100% of pipe capacity. To cut costs and give exacting control to piston speeds, specify MEAD DYNA-TROL valves to solve your flow regulating problems. For information on quick delivery, write to MEAD *today*.

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ASK YOUR MEAD MAN for more dollar-saving automation ideas

Circle 204 on Page 19

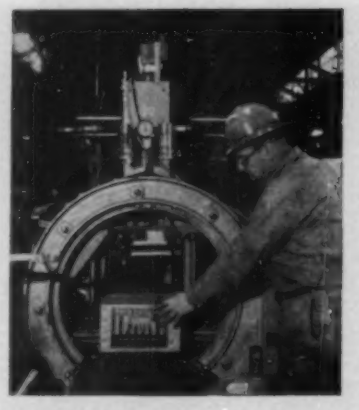
Pullmore Clutches offer

VERSATILE OPERATION

Use any actuation device — air, manual or electric. Rockford Pullmore Clutches start, stop, shift, reverse, inch, cycle and idle. They're used as main drives, auxiliary controls, and power take-offs for thousands of industrial machines. The Dual-Drive Clutches drive forward and reverse, attain high and low speeds, or control as clutch-brake combinations.

. . . FLEXIBLE DESIGN

High-torque compact design fits severe space limitations. Pullmore Clutches are available in single-drive or dual-drive units. The fast but smooth engaging clutches handle torque loads from 126 to 11,000 inch pounds . . . horsepower from 1 to 90 at 500 RPM. Sizes range from 1¾" to 8½" in diameter. Oil or dry operation. Write today for illustrated brochure.

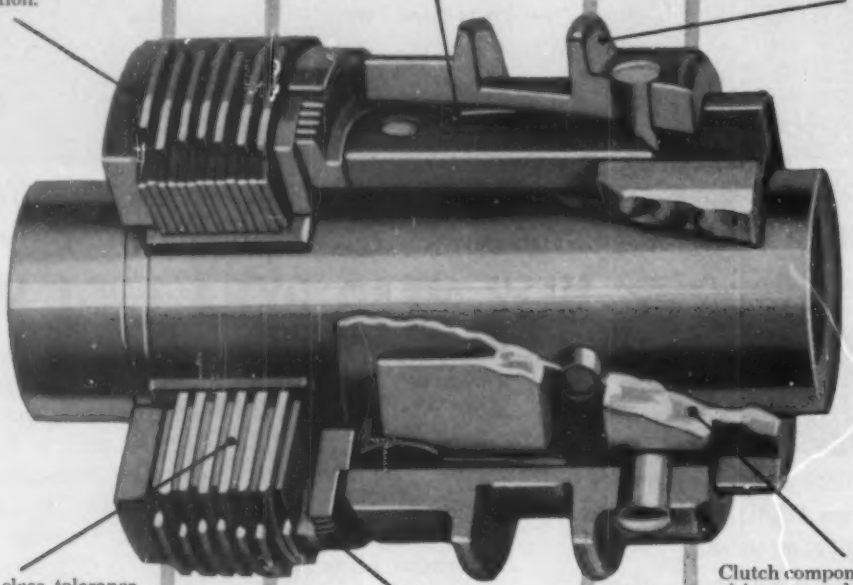


United States Steel Supply Model 12 Automatic Strapping Machine equipped with Rockford Dual-Drive Pullmore Clutch

Symmetrical design and precision machining assure smooth clutch operation. Torque is not affected by centrifugal force or direction of rotation.

Low axial pressure to levers gives positive, instantaneous engagement. High-ratio levers are case hardened forged steel. Immediate disengagement.

Use any actuation device — air, manual or electric. Slight pressure to shifting spool engages clutch. Spool length prevents binding and gives longer life.



Discs meet close tolerance flatness checks. Heat treated steel, graphite-impregnated bronze, sintered bronze or molded discs for oil and dry operation.

Easy Adjustment . . . simply raise locking spring and turn collar. Adjustment lasts for extra-long periods of heavy-duty service.

Clutch components are precision ground and highly concentric. Locking split ring assures positive axial positioning. Strong construction gives long, rugged clutch service.

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BW

DIVISION OF BORG-WARNER

Circle 205 on Page 19

Front Cover: From an ALGOL program to punched paper tape to the computer, and the job is done. Not so simple, says author David Evans, and cover artist George Farnsworth has superimposed an organizational chart on a common computer-input medium to emphasize the point.

October 26, 1961

Single Tire Replaces Duals 24

News Report—A major development in truck-tire design has been making inroads into the conventional dual-wheel setup; offers easier riding, better mobility and handling.

Learning to Live with a Computer 120

DAVID C. EVANS—Factors that determine success or failure of a computer installation.

Purchased-Parts Drawings 132

D. P. SIMONTON—How to treat parts specification and identification details in contracts.

Compression-Spring Design 138

ROY D. CHANDLER—A new, direct approach, including: Cookbook design methods, slide-rule procedures, standard spring materials, and allowable-stress data.

Synthetic Hydraulic Fluids 156

ROGER E. HATTON—A guide to selecting commercial and special-purpose fire-resistant hydraulic fluids: Characteristics, advantages, and typical applications.

Indicator Lights 160

JOSEPH L. SEMINARA—Selection of light displays, based on human-engineering factors.

Keeping Bolted Joints Tight 163

O. J. ZAMPARO—How to avoid decoupling of joints held together by threaded fasteners.

Designing Minimum-Section Columns 167

B. SAELMAN and A. E. RUBIN—*Data Sheet*—A simple, direct method for determining shape factors and optimum proportions of column sections under pure compression loading.

Additives in Lubricants 170

PETER KALIL—*Design Abstracts*—Lubricant additives: What they are and how they work.

CONTINUED NEXT PAGE

Measure of Success 119
COLIN CARMICHAEL—*Editorial*

Engineering News 6

Water-jet marine engine . . . 6
Blackboard drafting 8
O_2 generator for space 8
X-15 space booster 10
Compressed computer 12
Mach-400 shock tube 14
Show-visitor survey 15
Electric space engines 26
Refined lawn-mower engine . 28
Lunar surface vehicles 32

Trends 22
Picture Report 30
Industrial Design 34
Meetings and Shows 37
Short Courses and Symposia 40

Scanning the Field for Ideas 126

Reaction controls V-belt tension—chain forms piston rod in hydraulic actuator—arm supports wire in potentiometer—platen press cancels reaction forces—heat drives actuator piston—incline controls flow in fluid dispenser—transformer provides undistorted output—ball valve adjusts for wear—inlet line provides reversible flow for cooling pump.

Design in Action 149

Davits launch lifeboats by gravity—airplane controls steer jet-propelled yacht—mechanical finger automates hand valves—gun welds with polyethylene—manifold controls clutch—light spots gun-bore deviations.

Tips and Techniques

Repeating decimals 162
Wheel velocity 166

Design Abstracts 170

New Parts and Materials 188

Engineering Department Equipment 227

The Engineer's Library 233

Noteworthy Patents 237

Backtalk 248

Helpful Literature 181

Reader Information Service 17
Reprints 235
Advertising Index 247
Business Staff 247

IN THE NEXT ISSUE: How much freedom for engineers . . . double patenting . . . minimum-weight castings . . . audible-signal devices . . . thermal stresses . . . water-glycol hydraulic fluids . . . materials for shafts . . . powder-metal gears . . . nonuniform beams.

THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

October 26, 1961
Volume 33 — No. 22

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EDITORIAL OFFICES
Penton Building, Cleveland 13, Ohio

Branch Offices
New York, Detroit, Chicago, Pittsburgh, Washington, London

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Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

Economy record on wall phones duplicated on new telephone

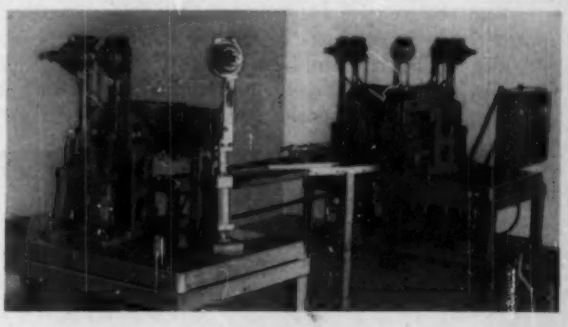
Western Electric had a ready answer for low cost assembly of the many components in the base of their new telephone. It had been developed by Western Electric engineers, with the help of TRS riveting experts, for a similar problem on wall phones.

It had paid off with a 35 percent labor saving and an 80 percent boost in production rate!

The Western Electric set-up described here is a production-proved example of what may be accomplished with the PAR Process . . . TRS Production Automated Riveting. Even though your assemblies are less complex, it will pay you to investigate the PAR Process. A TRS man may help you simplify and speed-up operations . . . minimize handling . . . decrease parts spoilage . . . through more automatic riveting and dependable quality TRS rivets. Often a TRS man can help achieve remarkable results from existing equipment. Always he'll have the style and size rivets you need.

11 Rivets Set in Complex Pattern in Only 2 Operations

Here is the specially engineered Multi-Head Riveter which helps cut costs for Western Electric. Eleven automatic riveting machines are combined with a specially designed rolling assembly fixture to minimize handling 5 parts of the assembly. In 2 operations, parts are attached to baseplate wih 11 TRS rivets in a complex pattern.



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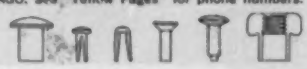
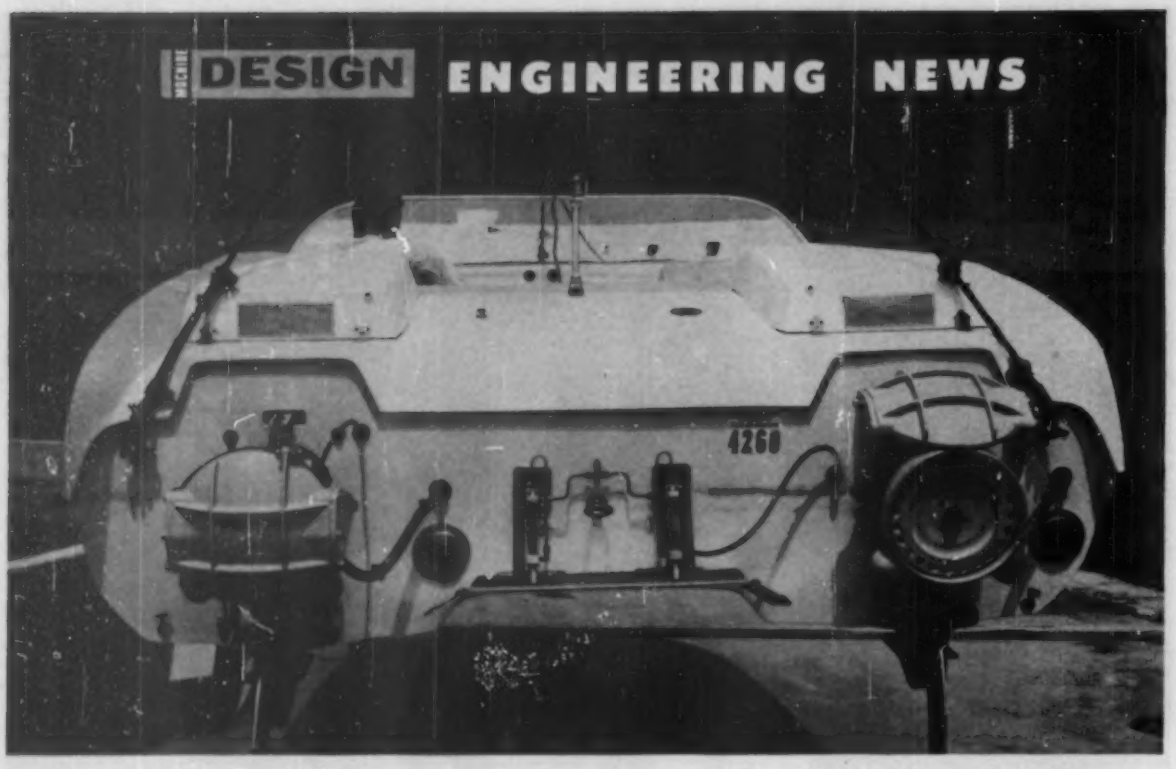
If it's a Tubular Rivet TRS makes it Better and Better





Above-Water Jet Pushes a Boat

AZUSA, CALIF.—Discharge of water into the air provides thrust in Hydrocket, a marine propulsion system for surface craft. Developed by Oceanics Div., Aerojet-General Corp., the device scoops up water and forces it through angled nozzles to drive boats faster and more economically than conventional propeller systems. Power is furnished by a standard reciprocating inboard engine.

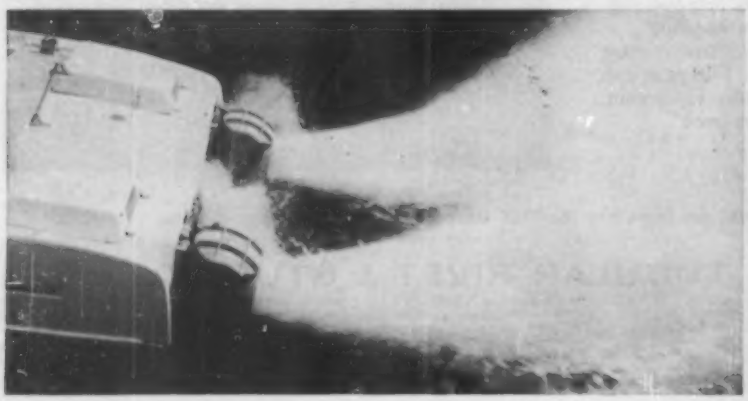
The discharge nozzles are located on the periphery of a rotating impeller which rides almost completely above the water line. The impeller is free of cavitation, a prime contributor to loss of propeller efficiency at high speeds. Efficiency of the water-jet is further boosted by extremely low pump losses, and the water scoop adds little drag; in fact, pressure recovery due to water ramming improves propulsion-system performance at high speeds.

Steering is by thrust vector control, and full thrust can be maintained through a turn. A reverse gate drops over the discharge nozzles to deflect the jet stream and stop or back up the boat. Shrouding the impeller keeps spray to a minimum.

The Hydrocket can be used with all sizes of boats and ships, according to Oceanics engineers. Excellent performance is obtained when the ratio of all-up weight of the boat to power developed does not exceed 17-20 lb per hp.

Dual Hydrockets were performance tested on a catamaran hull: Unit on the left is in reverse gear: When the reverse gate is lowered, the water jet is deflected under the boat.

Spray kicked up when the two Hydrockets are in forward gear creates a rooster-tail effect (left). When the reverse gate is down, water discharges through the two nozzles in the lower part of the impeller unit (right), and much less spray is formed. Intake water is scooped up at ram pressure beneath the hull.



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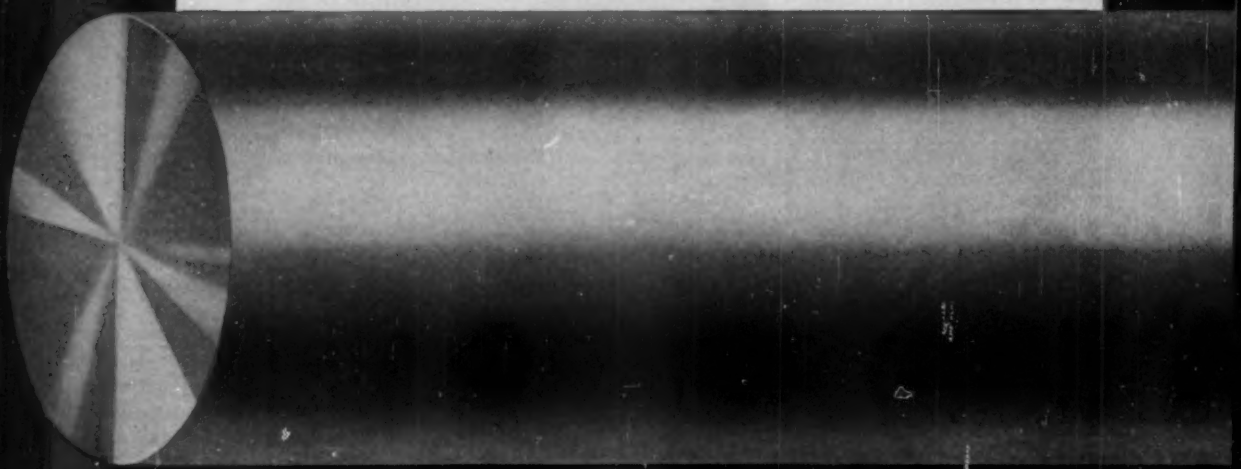

Here are cost-reducing advantages

(1) Heat treating problems, costs (and secondary operations) are eliminated. (2) "e.t.d." 150 machines better than heat treated in-the-bar alloy steels. (3) Tool life and finish are excellent. (4) No quench cracks or distortion from heat treatment. (5) "e.t.d." 150 has exceptional strength and hardness uniformity across the bar. (6) End cost of parts is greatly reduced.

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Circle 207 on Page 19

Chalk Up Drafting as a Blackboard Technique

CHICAGO—Designers work at blackboards, not drawing boards, at TAB Engineers Inc., a midwest consulting firm. By gang tackling design problems, they slash time and costs of board work by 50 per cent.

Each man has a specific assignment, and as he develops his ideas he puts them on display. The project manager can see the product take shape in its entirety, instead of inspecting drawings one at a time. If a change is needed, it can be made before it influences parts not yet drawn up.

Similar to the brainstorming sessions used in advertising agencies, the technique is claimed to raise creativity and efficiency. "By seeing how his portion of the design fits the whole pattern, the designer is stimulated to work better himself," according to H. A. Edmonds, TAB's vice president and director of engineering. "And he can frequently help his fellows by suggesting improvements in their phases of the project."

When a satisfactory design is developed, a detailed drawing is made immediately by overlaying a ruled plastic sheet, sketching other views, and adding dimensions. The blackboards are then photographed.

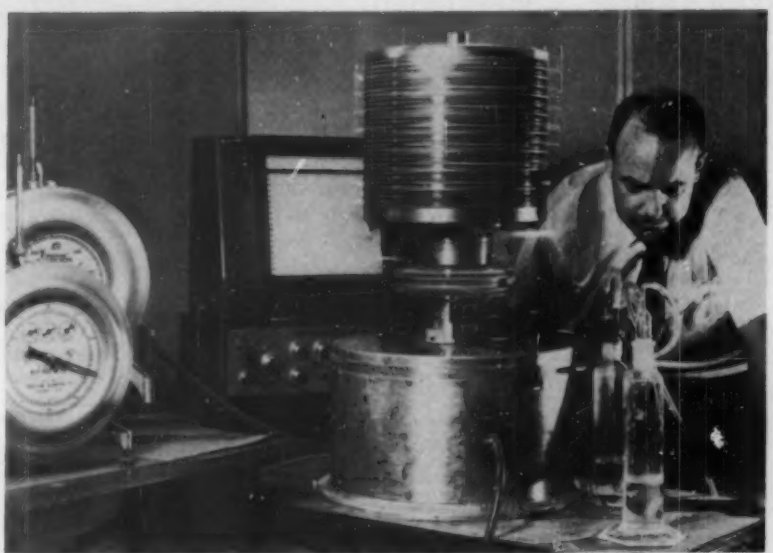
There are no drawing boards in TAB's drafting room. At left, designer is discussing ideas with his supervisors. At right, specifications are being checked against sketch on the rear board. At camera, the blackboard design is being photographed for a permanent record. TAB estimates that the new technique could save industry some $6 billion of its annual engineering budget.

Equipment requirements are few: Wall-size blackboards, drawing instruments made for blackboard use, and photographic equipment. The difficult part in changing over from conventional drafting methods involves developing the needed patience and skill, according to Mr. Edmonds. Getting the engineers and designers to accept the new method is the biggest problem.

Final Link for a Deep-Space Oxygen Generator

COLUMBUS, OHIO—A rotating electrolytic cell, developed by Battelle Memorial Institute, may be the last piece of hardware needed in a workable system that will convert an astronaut's breath into breathable oxygen. Designed for use on two-man space trips lasting up to two years, the device breaks down water into hydrogen and oxygen. It would be coupled with another Battelle device that requires hydrogen input and converts carbon dioxide into carbon and water. Each unit would feed the other.

Unique feature of the new cell is its ability to operate efficiently independent of natural gravity. Conventional electrolytic cells depend on gravity to separate gas bubbles from the generating liquid, but the Battelle device uses centrifugal forces produced by rotation for the same purpose.



Rotating at 500 rpm, the drum-shaped electrolytic cell is made up of 16 individual cells stacked like pancakes. It produces two quarts of water per day from a 500-w input. Hydrogen and oxygen are generated on separate electrodes.

. . . Fluid Power news

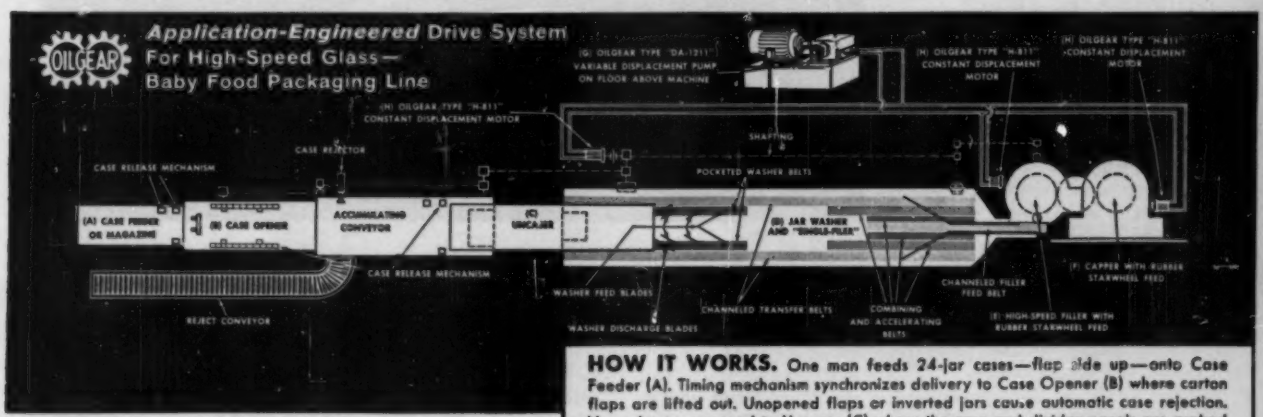
OILGEAR 40 Years of Fluid Power

REPORT NO. 11,303 From Oilgear Application-Engineering Files

HOW OILGEAR SYSTEMS *on Gerber's Integrated Glass Lines* BOOST OUTPUT—CUT COSTS

USER: *Gerber Products Company, Fremont, Michigan; Rochester, New York; Oakland, California*

DATA: To sharply reduce breakage, jam-ups, downtime, and labor costs in filling glass baby food jars at higher speeds, Gerber's Engineering Research Department developed the first fully integrated, high-speed machine for packaging foods in glass economically, under completely automatic control. *Drive Requirements for this multi-unit machine were outlined as follows:* 1. Complete synchronization of the seven integrated units through three drives—at the Uncaser, Filler, Capper. 2. Positive, precise, remote pneumatic control of operating speed that is instantly, infinitely variable from very slow to top speed while the machine is running. 3. Controlled acceleration and deceleration to prevent jars from tipping and jamming, eliminates spillage, reduces machine strain. 4. Compact, for maximum work area. 5. Independent operation of Filler and Capper drives to facilitate cleaning. 6. Trouble-free, dependable, long-life operation, immune to frequent sanitary washdowns, fully enclosed to prevent food contamination.


OILGEAR
Application-Engineered Drive System
For High-Speed Glass—
Baby Food Packaging Line
(G) OILGEAR TYPE "DA-1211" VARIABLE DISPLACEMENT PUMP ON FLOOR ABOVE MACHINE
(H) OILGEAR TYPE "H-811" CONSTANT DISPLACEMENT MOTOR
(H) OILGEAR TYPE "H-811" CONSTANT DISPLACEMENT MOTOR
(H) OILGEAR TYPE "H-811" CONSTANT DISPLACEMENT MOTOR
SHAFTING
POCKETED WASHER BELTS
CASE RELEASE MECHANISM
CASE REJECTOR
(A) CASE FEEDER OR MAGAZINE
(B) CASE OPENER
ACCUMULATING CONVEYOR
(C) UNCASER
(D) JAR WASHER AND "SINGLE-FILER"
(F) CAPPER WITH RUBBER STARWHEEL FEED
CASE RELEASE MECHANISM
WASHER FEED BLADES
CHANNELED TRANSFER BELTS
COMBINING AND ACCELERATING BELTS
CHANNELED FILLER FEED BELT
(E) HIGH-SPEED FILLER WITH RUBBER STARWHEEL FEED
REJECT CONVEYOR
WASHER DISCHARGE BLADES

HOW IT WORKS. One man feeds 24-jar cases—flap side up—onto Case Feeder (A). Timing mechanism synchronizes delivery to Case Opener (B) where carton flaps are lifted out. Unopened flaps or inverted jars cause automatic case rejection. Normal cases proceed to Uncaser (C) where the case and divider panels are pushed down and away from the jars. Uncaser deposits jars on transverse-channeled conveyor platens. Blades slide jars from channeled platens into pocketed belts which hold jars inverted through Washer (D). Jars are plowed from washer belt pockets to transverse-channeled combining and accelerating belts—moving 350 to 400 jars per minute . . . are then "shuffled" into the "Single-Filer"—550 to 650 jars per minute on a channeled belt to Filler (E). Rubber starwheels minimize breakage in feeding the 25-pocket Girdler Filler (E), and 16 twin-head Anchor-Hocking rotary Capper (F) . . . both custom-built for Gerber with center-to-center jar spacing for positive, smooth glass transfer between units. Smooth synchronization, cushioned acceleration and deceleration provided by the Oilgear Drive and Control System, combined with no jar-to-jar contact make possible the almost noiseless higher speeds and virtual elimination of glass damage . . . for if even a single jar or bottle is broken in food or pharmaceutical operations, a complete and costly shutdown, cleanup and inspection of the packaging line by quality control personnel is required.

SOLUTION: An Oilgear "*Any-Speed*" Drive, consisting of a Type "DA-1211" variable displacement pump and three Type "H-811" constant displacement motors—powers all elements of "The Gerber Integrated Glass Lines" to *meet and exceed originally specified drive requirements.* For maximum work area around the "Glass Line," prevention of possible food contamination, and use of an economical electric motor, the Oilgear "*Power-Pak*" is located on a different floor of the building. A compact control panel located at the Filler enables the operator to start, stop, jog, and instantly vary speed of the entire machine through an infinite range while the machine is running—thereby obtaining maximum efficiency for the consistency of the food being filled. The drive system automatically synchronizes the speed of all seven machine units. Operating speed ranges from 550 to 650 jars per minute—depending entirely upon the products being filled . . . *an increase of up to 23% over former conventional glass packaging methods.*

GERBER REPORTS—"*The major advantages of this newly developed equipment are: less shock and scratching of jars, which reduces damage; substantially higher speeds: more thorough washing; lower maintenance cost and automatic control of all segments of the line.*"

Due to the smooth, cushioned application of power, even at higher speed, reduced glass damage and the resulting reduction in downtime, maintenance and labor costs with this Oilgear-powered, Gerber-designed machine, an expanded installation program of these "Integrated Glass Lines" is now under way at all Gerber plants.

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

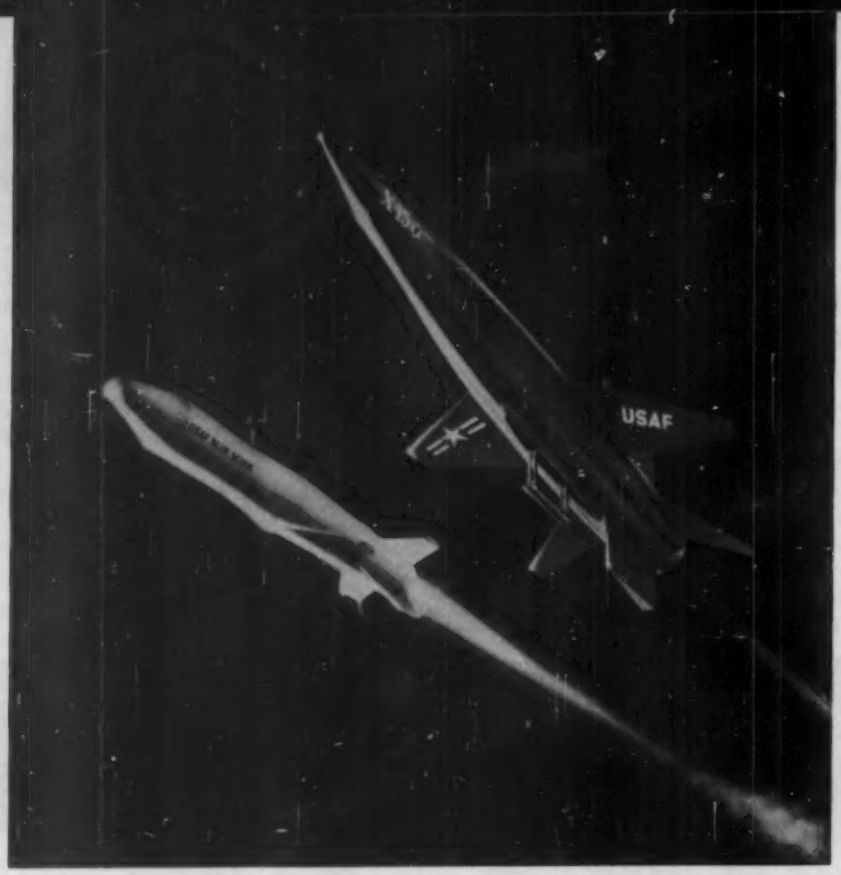
"PLUS" features of this Oilgear Drive and Control System are: dual, automatic, built-in hydraulic and electric overload protection—stops the machine in event of jamming or malfunction . . . automatic hydro-dynamic braking . . . direct torque reading at the control panel . . . constant pressure and flood lubrication with continuous power fluid filtration . . . complete flexibility for location of drive and control components . . . fast, easy installation . . . standard drive and control components sealed against washdowns . . . lower power consumption—using only power in proportion to work performed. There are many more—but these alone should be sufficient proof why designers and builders of machinery are turning to Oilgear, and say . . .
"*for the lowest cost per year—it's OILGEAR!*"

For similar practical solutions to YOUR linear or rotary Controlled Motion problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY

Application-Engineered Controlled Motion Systems

1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN



The X-15 rocket plane can launch the Blue Scout on missions that would take the missile 100,000 nautical miles from earth. The system would cut costs of guided Blue Scout launches by two thirds, of unguided probes by one half.

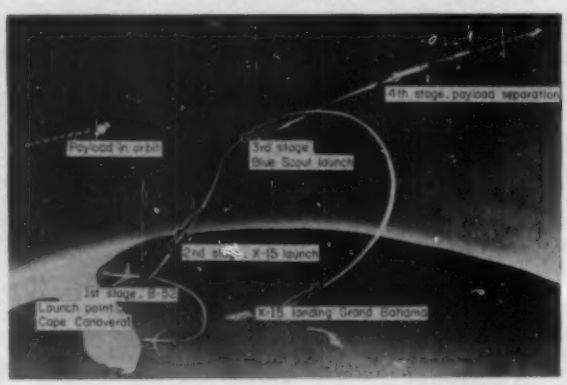
X-15 May Boost Scout into Space

Los Angeles—By air-launching the Blue Scout rocket from the X-15 manned aircraft, the Air Force may soon piece together the world's first recoverable space-booster system. A study conducted by Aeronutronic Div., Ford Motor Co. (prime contractor for the Blue Scout), and Los Angeles Div., North American Aviation (builder of the X-15), shows the system to be feasible for launching deep-space probes and both orbital and suborbital flights.

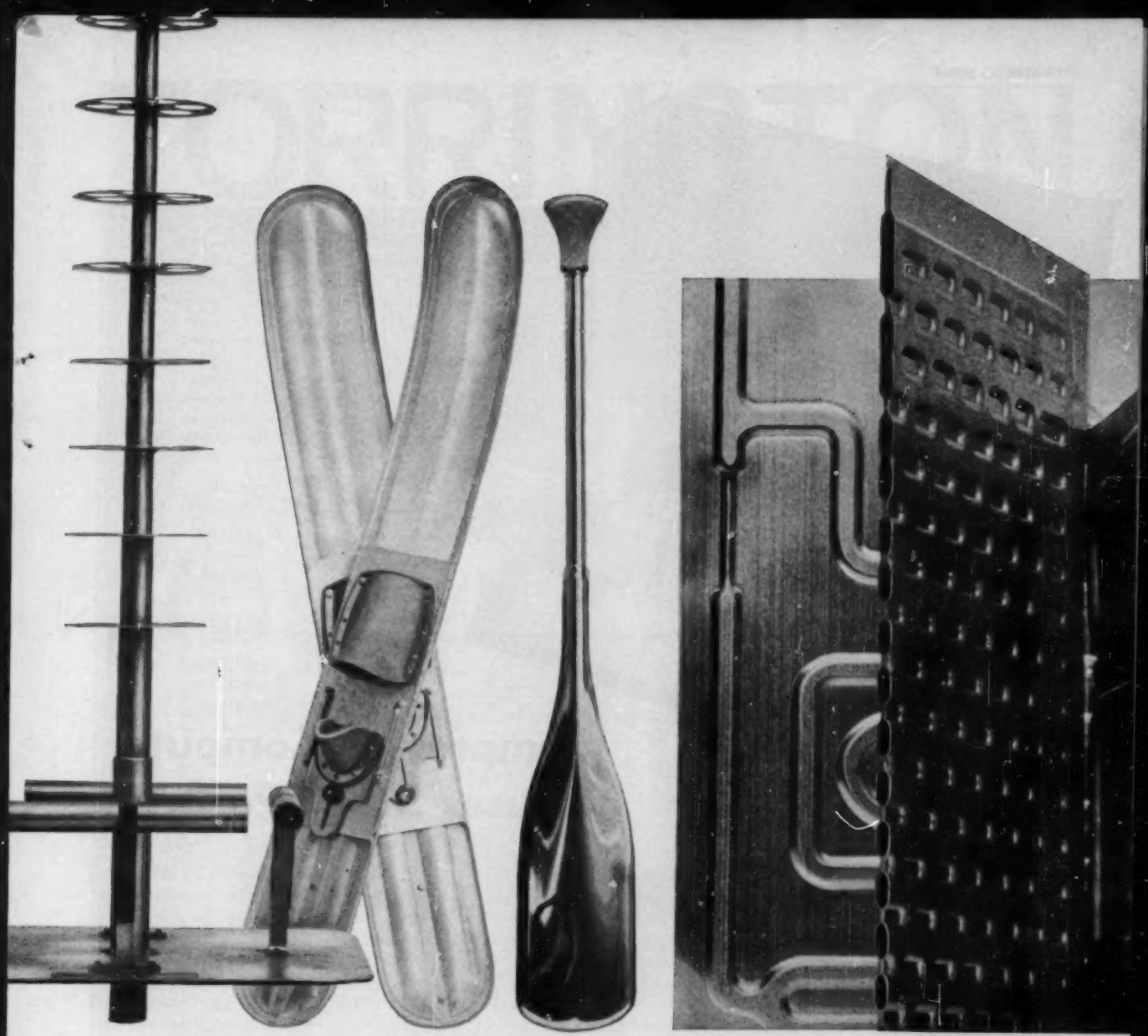
The Boeing B-52 jet bomber would act as the main-booster stage of a four-stage vehicle. It would launch the X-15, and the rocket plane would fire the two-stage Scout. Both aircraft would return to earth for normal pilot-controlled landings.

In a typical mission, the B-52 would release the X-15 at an altitude of about 45,000 ft. The rocket ship would then gain altitude and speed (156,000 ft, 2800 mph would be typical) before triggering the Blue Scout. The X-15 would coast to about 300,000 ft and then re-enter, completing re-entry at 80,000 ft and 1840 mph. The Blue Scout would roar up to fourth-stage payload separation, and the payload would continue into orbit or deep space, depending on the requirements of the mission.

"If an abort occurs while the X-15 is being carried by the B-52, the entire system could be safely returned to base," according to E. W. Johnston, chief aerodynamicist on the X-15 project. "If the abort occurs after the X-15 is released, the Blue Scout will be jettisoned. Command destruct receivers will be provided in the missile to enable destruction in the event of erratic flight."



When the system is test "fired" down the Atlantic Missile Range, the B-52 will take off from Cape Canaveral and land at Patrick Air Force Base. The X-15 will coast to 300,000 ft after launching the Blue Scout, then re-enter the atmosphere and land at Grand Bahama Island. With the test set up for a 60-degree launch angle the Scout will go into deep space. With a 30-degree launch, the Scout would achieve the highest apogee for light space-probe payloads and put heavy payloads into orbit.



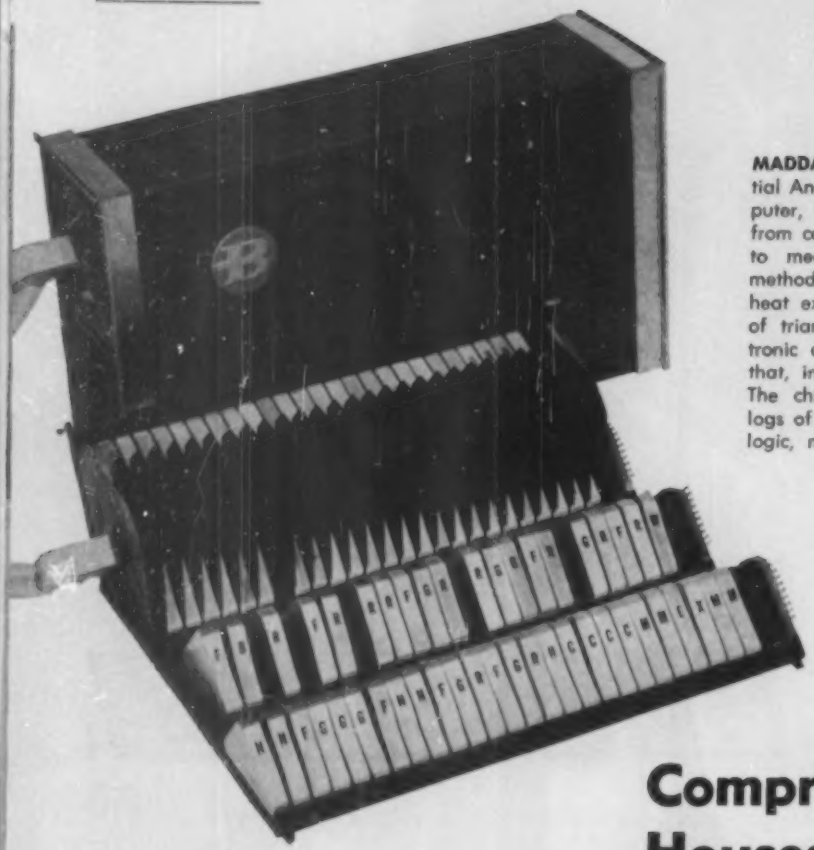
What's next?

Although Roll-Bond is still largely utilized in the heat exchanger field, creative engineers are gradually discovering that the Roll-Bond principle is ideal for many processes—especially where strength and lightness are vital factors. Now, Roll-Bond uses range from refrigerators to radar antennae, from water skis to boat paddles. What's next? We're never sure. Maybe you're the designer that will see the solution to one of your company's problems in Roll-Bond—where a product can be made better for less money—or dream up an entirely new creation. As you know, any continuous tubing pattern you can draw on paper can be made into a homogeneous sheet of aluminum or copper Roll-Bond. Intriguing?

Olin
METALS DIVISION

For information, write Sales Manager, Roll-Bond Products, Olin Mathieson Chemical Corporation, East Alton, Ill.

Circle 209 on Page 19



MADDAM (for Macro-Module and Digital Differential Analyzer Machine), Burrough's new baby computer, has unusual flexibility. Because it's built from commercial components, it can be expanded to meet changing needs. The Macro-Module method of high-density packaging uses a finned heat exchanger as a central element in a "log" of triangular chips. The chips, containing electronic circuitry, plug into a printed-circuit board that, in turn, is wrapped around the exchanger. The chips fold snugly between the fins. Two logs of chips, each 3 x 3 x 10 in., contain all the logic, memory, and other working circuits.

Compressed Computer Houses 5500 Parts

PAOLI, PA.—Burroughs Corp. is demonstrating a special-purpose computer the size of a loaf of bread. With a new technique for compressing components into smaller spaces, company engineers say general-purpose machines can be housed in a package no larger than a desk.

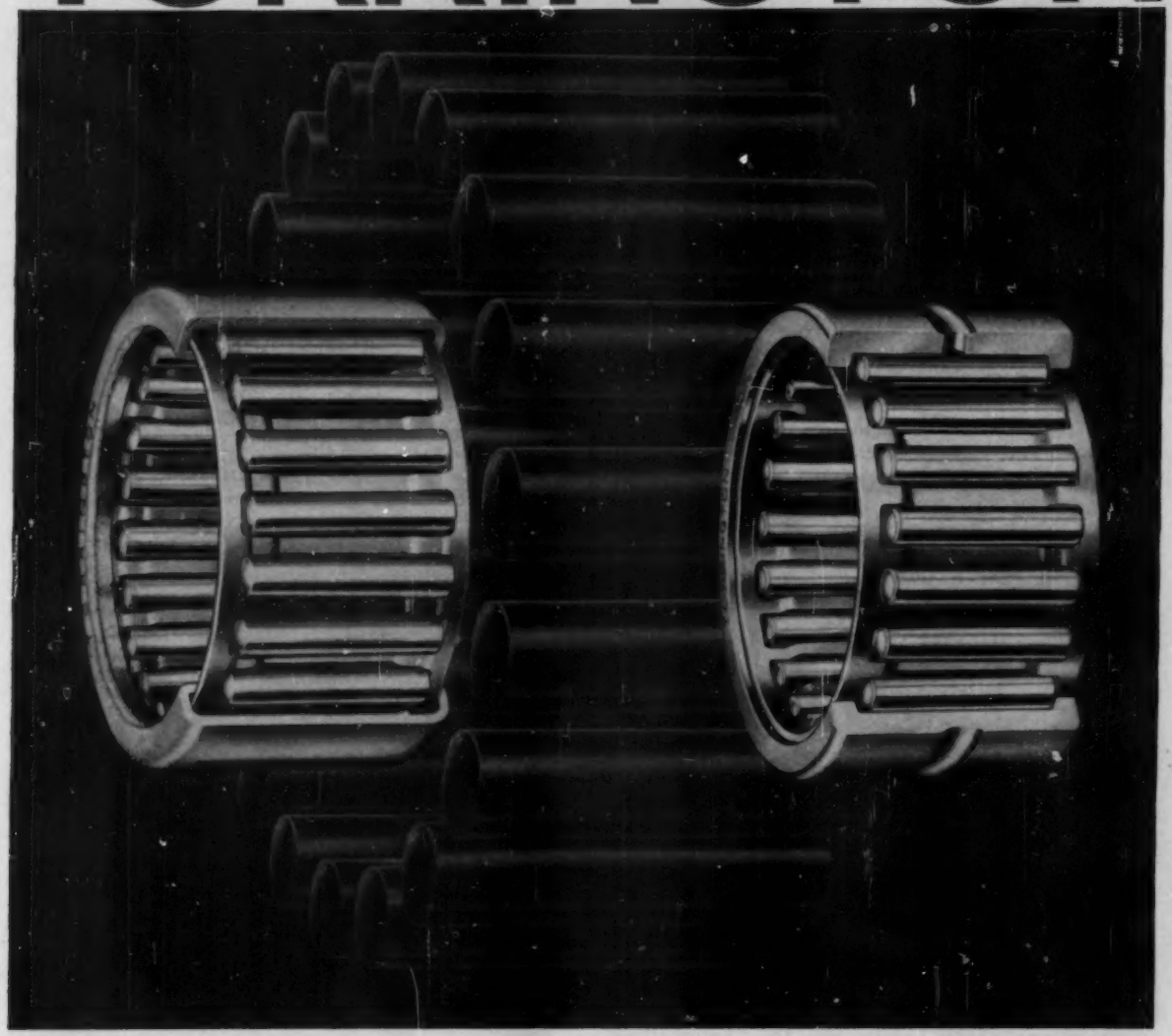
Design is based on Burroughs' Macro-Module system of high-density packaging (MD, May 25, 1961, pp. 24-29). Only commercially available components are used; off-the-shelf items make the device easy to manufacture and assure replacement parts will be available if servicing becomes necessary.

Although tiny, the 12-lb special-purpose machine is a powerful tool. It is capable of solving integral and differential equations, and it will make 33,000 calculations per sec. All of the 5500 components are housed within a 3 x 6 x 11-in. space—at a density of 69,000 parts per cu ft.

Developed to solve commercial and military problems that call for instantaneous decisions, the tiny brain is the first fully miniaturized unit to be shown in actual operation. As set up for the demonstration, it could be installed in an airplane, spacecraft, or missile to tackle target chase-and-catch problems. According to Burroughs, it shrinks the single-purpose computer to a size that is practical for airborne applications, and the company is studying methods of tailoring it to many military jobs.

The high-density computer occupies about the same volume as a loaf of bread. Designed for special-purpose work, it makes 33,000 calculations per sec—about as fast as room-size systems. According to Burroughs, it will be used in aircraft, missiles, and space vehicles.

TORRINGTON



WHATEVER THE DUTY...TORRINGTON HAS A BEARING FOR IT

Take these two bearings:

The unique Torrington Drawn Cup Roller Bearing opens new design possibilities in alternators, power-tool motors, electric mixers, vacuum cleaners and a host of similar products. It is so light, compact and efficient that designers have more flexibility than ever before. Yet the Drawn Cup Roller Bearing costs less than any other anti-friction bearing of comparable performance. In many cases, armature bearing costs have been reduced as much as 50%.

The Torrington Heavy Duty Roller Bearing is ready when the going is tougher. Controlled Contour rollers insure uniform loading and prevent stress concentration at the roller ends. A patented flange-riding retainer insures positive roller guidance and provides ample lubricant storage area. Torrington Heavy Duty Roller Bearings have proved highly successful in two-cycle engines, hydraulic pumps, oil-field equipment and transmission systems.

These are just two examples of Torrington's outstanding capability in bearing design and manufacture. Remember that Torrington makes **every** basic type of anti-friction bearing... can supply the bearing that's **exactly** right for your application. Don't hesitate to call us for advice.

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY Torrington, Connecticut • South Bend 21, Indiana

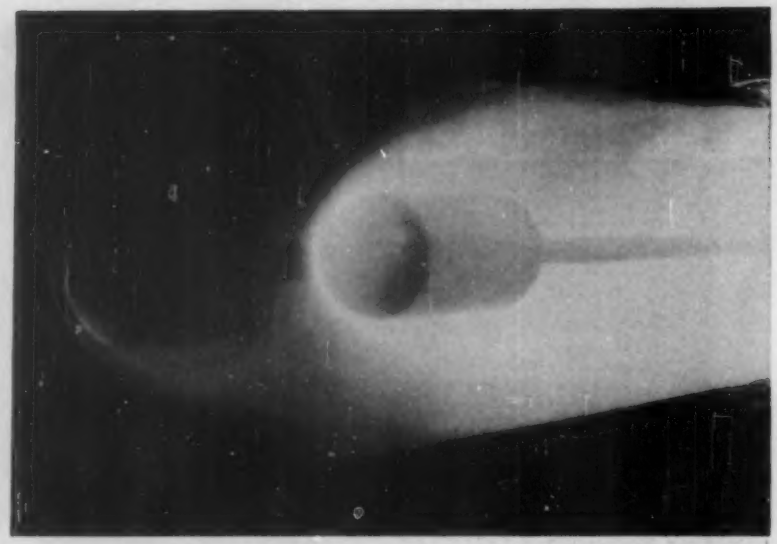
Circle 210 on Page 19

Mach-400 Shock Tube Shows All the Action

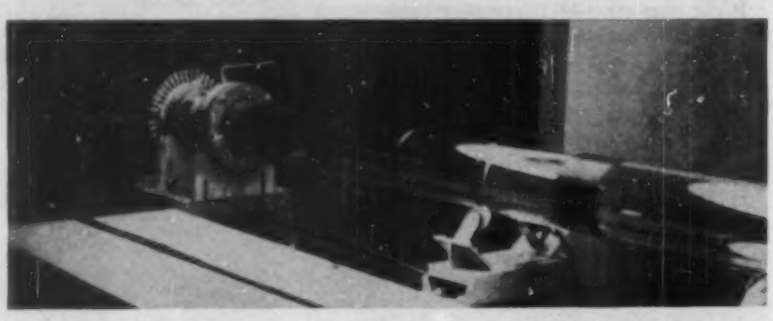
PALO ALTO, CALIF.—Using all-glass shock tubes, scientists at the Lockheed Missiles and Space Co. research laboratories are simulating spacecraft re-entry at speeds greater than Mach 400 (280,000 mph). Passage of the shock waves through the gas (air or nitrogen at 0.0001 atmosphere) creates temperatures on the order of 100,000 K.

Glass tubes are used, according to Lockheed, to permit direct observation and to allow photographic study from any angle. Time exposures of the shock-heated gas-radiation patterns can record the entire event, and high-speed cameras can capture various phases of the impact on the scale-model re-entry vehicles. More information can be gleaned from the tests than would be possible with traditional metal shock tubes having a single small window.

The tube, measuring 6 in. ID x 10 ft long, has its own capacitor bank that is capable of storing 60,000 joules of electrical energy. The shock wave is driven by electromagnetic forces generated when the capacitors are discharged.



Nose-cone model burns its way through a Mach-400 shock wave. Taken from 45 degrees ahead of the target, the time exposure shows the entire event as a shock wave hits and passes over the re-entry body. Faint image at left is a reflection of the glowing cone on the far wall. New all-glass shock tube (below) lets researchers view test models from all possible angles.

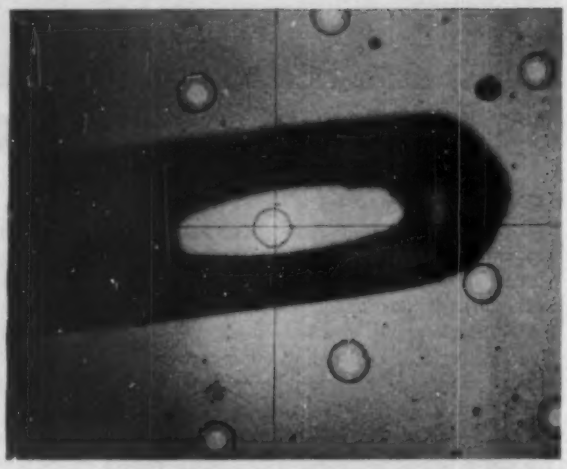


Glass Film Preseals Thousands of Tiny Transistors

POUGHKEEPSIE, N. Y.—Glass powder can now be melted on semiconductor wafers to seal thousands of microminiature transistors and diodes at one time. The technique, developed by Components Div., International Business Machines Corp., reduces manufacturing costs by turning out components as reliable as those that are individually encapsulated in glass or plastic, or enclosed in hermetically sealed containers.

The solid-state devices are "grown" in the normal manner—they are built up on a silicon wafer and covered by a thin protecting layer of silicon oxide. Before the wafer is cut up, however, it is coated with glass powder and heated to 1500 F. Later, during cooling, the molten glass forms a 0.0001-in. film that seals the device against the atmosphere; the pinhole-free film resists moisture and chemicals found in the air.

After the glass film hardens, the wafer is ultrasonically sliced into components, each component retaining its permanently sealed sensitive surfaces. Electrical contacts are then added by etching tiny holes through the glass and oxide. About 1000 components can be sliced from one nickel-diameter wafer.



Solid-state components sealed by the new IBM glass-melt technique are so tiny that one can be framed in the eye of a needle. About 1000 can be cut from a wafer the diameter of a nickel.

Engineers Prefer Straight Facts To Round Figures at Trade Shows

NEW YORK—When they visit industrial expositions, engineers would rather see a working (mechanical) model than a model (female) working. This preference was brought to light in a survey of visitors to the Design Engineering Show in Detroit last May. Desires and needs of the men who attend such shows have been published by show managers Clapp & Poliak Inc. in a booklet titled "What They Want." Nine major "wants" — areas in which many exhibits could stand improvement—are:

Technically qualified booth personnel. Design engineers expect thoroughly knowledgeable answers to their questions from experts. They resent talking only to salesmen who cannot furnish technical data.

Alert and well-trained people. Booth personnel must not only have answers but must be cordial and personable, and—even after nocturnal entertaining—must be on their toes, not out on their feet.

Less high-pressure selling. Product-hawking repels design engineers.

Fewer pretty girls. A girl who knows a canned speech and nothing else is no help to an engineer seeking specific data. "I like pretty girls," says one show-goer, "but they are useless as a source of information."

A maximum number of products and their features. An exhibit showing many products, how they are made, and what they can do, is best. A "static" exhibit is considered little better than a catalog.

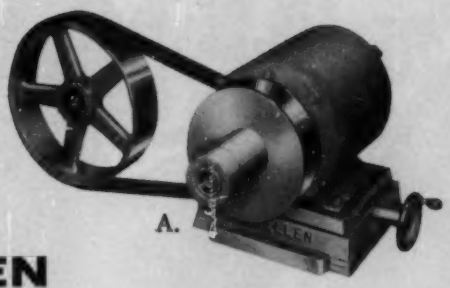
More product applications. Engineers come to get ideas, and they want to see products in action.

Better technical literature. Printed matter flows from booths to visitors—and often to trash cans—at a phenomenal rate. Technically complete data, with illustrations and product-application information, has the best chance of survival.

Information on newest products and R & D activities. Design Show visitors suspected that some exhibitors were "holding back on their latest developments."

Exhibits that are convenient to study and understand. Since time is limited, a show visitor prefers a "practical, orderly display."

FACT



A.

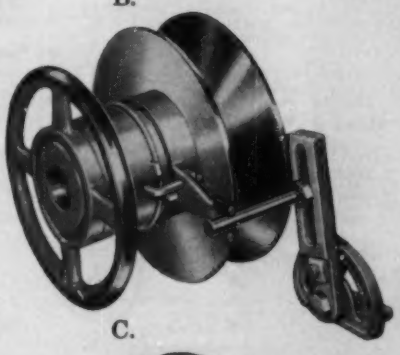
LEWELLEN VARIABLE SPEED PULLEYS

provide infinitely adjustable machine speeds *for direct and effective product control.*

B.

FACT

Lewellen Variable Speed Pulleys connect motor and machine . . . track a V-type belt at infinitely adjustable pitch ratios . . . are spring loaded and self-adjusting (B), or ball bearing loaded and manually adjustable (C) . . . used singly for moderate speed ranges (A), or in pairs for wider speed ranges (D).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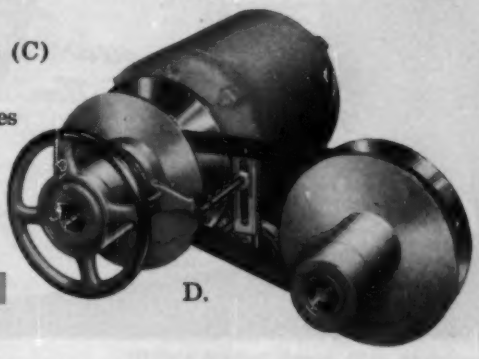
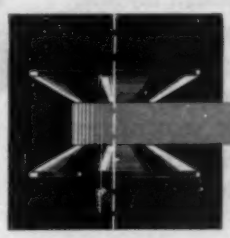

D.

FACT

Lewellen Variable Speed Pulleys scale compactly . . . install easily . . . perform predictably . . . incorporate operational control.

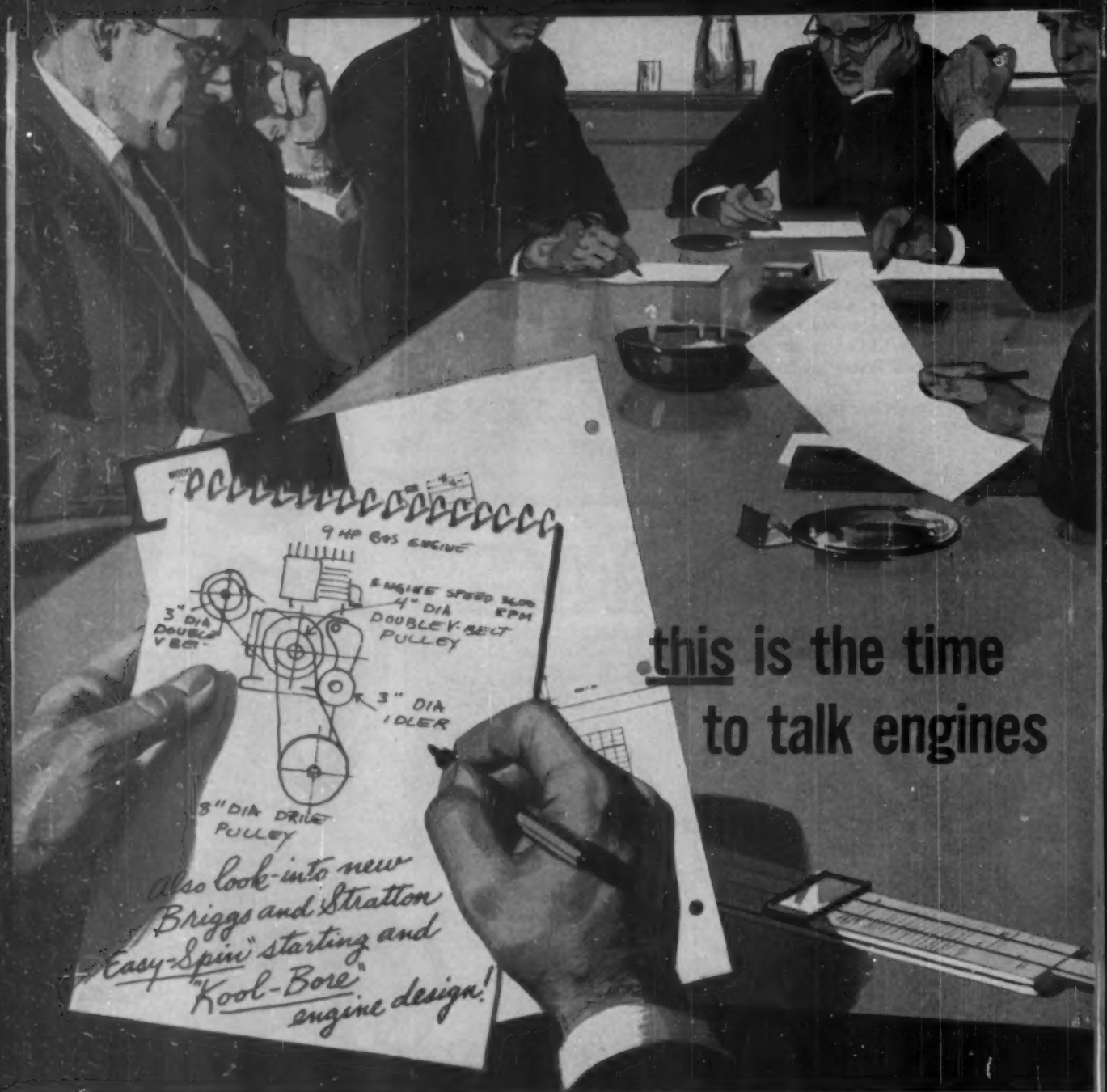


Catalog 70 clearly defines and dimensions performance characteristics. Please write for it.

LEWELLEN

Manufacturing Company, Columbus, Indiana
Distributors in all Industrial Areas

Circle 211 on Page 19


9 HP BUS ENGINE
ENGINE SPEED 3600 RPM
4" DIA DOUBLE V-BELT PULLEY
3" DIA DOUBLE V BELT
3" DIA IDLER
8" DIA DRIVE PULLEY
Also look-into new Briggs and Stratton "Easy-Spin" starting and "Kool-Bore" engine design!

this is the time to talk engines

when you start your thinking . . . start planning with Briggs & Stratton

NEW PRODUCT IDEAS in the works? A suggestion — when you start your power equipment design layouts, use the detailed Engine Specifications available from Briggs & Stratton. Also available is Briggs & Stratton's Consulting Engineering Service with almost four decades of small engine power application experience. Write or phone Hugh S. Brown, Engineering Vice President, Briggs & Stratton Corp., Milwaukee 1, Wisconsin. (Phone LOcust 2-5000)

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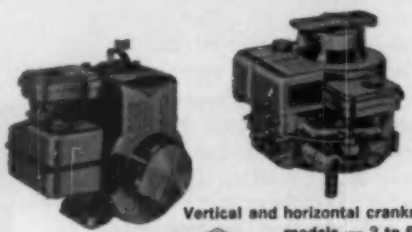

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Descriptions of items start on Page 181. Starred items are from Oct. 12 issue.

Electrical, Electronic

601 Transfer Switches, Timers. 4 pp. Zenith Electric Co.

605 Electric Components. 12 pp. Wabash Magnetics Inc.

606 Aluminum Boxes and Covers. 8 pp. Zero Mfg. Co.

608 Relays, Timer Products. 64 pp. Telex/Aemco, Div., Telex Inc.

615 Synchros, Rotary Components. 40 pp. Clifton Precision Products Co. Inc.

616 Electro-Optical Component. 12 pp. Industrial Components Div., Raytheon Co.

622 Solid-Cast Stators. 8 pp. U. S. Electrical Motors Inc.

623 Trimmer Capacitors. 16 pp. Erie Electronics Div., Erie Resistor Corp.

626 Automatic Data Logger. 4 pp. Bristol Co.

628 Plastic Wire Connectors. 4 pp. Ideal Industries Inc.

631 Electronic Connectors. 6 pp. Electronic Sales Div., DeJur-Amsco Corp.

689 Precision Instruments.* Lists new-product data on instruments and special products. "Heli-News," 8 pp. Helipot Div., Beckman Instruments Inc.

690 Multiple Switches.* Illuminated and non-illuminated types. Catalog S-306, 12 pp. Switchcraft Inc.

691 Adjustable-Speed Drives.* Definition, comparison, selection from 1/20 to 1000 hp. Bulletin GEA-6999, 32 pp. General Electric Co.

692 Gyroscopic Instruments.* Theory, performance, application, testing. "Technical Information for the Engineer—Gyros," 60 pp. Kearfott Div., General Precision Inc.

693 Servo Components, Packages.* Outline drawings, electrical characteristics. 16 pp. Transicoil Div., Daystrom Inc.

694 Silicon Diodes, Rectifiers.* Data on diffused-junction diodes and rectifiers. Bulletin 514, 10 pp. Erie Resistor Corp.

695 Differential Transformers.* Theory, application of Atcotran units. Bulletin 6208, 12 pp. Automatic Timing & Controls Inc.

696 Panel Instruments.* Covers 2½, 3½-in. matched instruments. Bulletin 01-111, 6 pp. Weston Instruments Div., Daystrom Inc.

697 Silicon Rectifier.* Discusses IN 3289-3295 high-current unit. Sheet 145.15, 8 pp. Rectifier Components Dept., General Electric Co.

698 Switch, Thermostat Packages.* Covers 42 Klixon packages. Bulletins PRSW-108, PRET-26, 16 pp. Metals & Controls Inc., Div., Texas Instruments Inc.

699 Multiple Connectors.* Fastin-Faston, Ampeez, and Amp-Lok units. 6 pp. AMP Inc.

700 Basic Switches.* Describes Type M, 22-amp units. 2 pp. Micro-Switch Div., Minneapolis-Honeywell Regulator Co.

701 Germanium Diodes.* Covers 150 Gold Bonded diodes of various types. Bulletin A-101, 4 pp. National Transistor Mfg. Co.

702 Digital Transducers.* Dynapar Rotapulsers for use to 2400 pulses per rotation. Bulletin 200-A, 4 pp. Louis Allis Co.

703 Numerical Control System.* Command Control tape-control system. 4 pp. Electro-Mechanical Div., Lear Inc.

704 Control Centers.* Guide for layout of standard or special centers. Bulletin C-6300, 16 pp. Monitor Controller Div., Atlee Corp.

705 Speed Changer.* Vari-Tex unit described. Bulletins 51B90618, 51B1042, 6 pp. Allis-Chalmers Mfg. Co.

706 Servo-Motor Package.* Includes hydraulic motor, servo valve, internal relief valves. Bulletin A5261, 4 pp. Aero Hydraulics Div., Vickers Inc., Div., Sperry Rand Corp.

Hydraulic, Pneumatic

603 Solid Lubricants. 8 pp. Alpha-Molykote Corp.

604 Ball Valves. 32 pp. Hills-McCanna Co.

612 Hydraulic Motors. 4 pp. Aero Hydraulics Div., Vickers Inc., Div., Sperry Rand Corp.

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625 Hydraulic Rubber Hose. 14 pp. Titeflex Inc.

627 O-Rings. 4 pp. Irving B. Moore Corp.

630 Remote Valve Control. 20 pp. Stow Mfg. Co.

707 Hose Connectors.* Stock units of flexible metal. Bulletin 26, 4 pp. Atlantic Metal Hose Co. Inc.

708 Lubricating Grease.* Principles, rules for selection and application. 32 pp. Bardahl Mfg. Corp.

709 TFE O-Rings.* Specifications for over 250 sizes. Catalog P-1A, 4 pp. Chicago Gasket Co.

710 Fluid Steering Control System.* Data for Orbitrol system. 8 pp. Char-Lynn Co.

711 Lubricating Devices.* Oilers, valves, mist systems. Catalog 61, 12 pp. Trico Fuse Mfg. Co.

712 Control Valves.* In sizes from ¼ to 6 in. Catalog DVC-1, 8 pp. OPW-Jordan.

713 Fluid Filters.* Toll-Tole units described. 8 pp. Rosaen Filter Co.

714 Spray Nozzles.* Auto Jet units for pressures to 600 psi. Bulletin 115, 4 pp. Spraying Systems Co.

715 Heat Exchangers.* One, two, and four-pass units. Bulletin F-1161, 4 pp. Basco Inc.

716 Differential Pressure Devices.* Bellows-type units for use in various fields. Bulletin G-61, 28 pp. Industrial Instrument Corp.

Mechanical Equipment

607 Plastic Balls. 4 pp. Ace Plastic Co.

610 Electromagnetic Disc Brake. 4 pp. Stearns Electric Corp.

617 Miniature Ball Bearings. 48 pp. New Departure Div., General Motors Corp.

618 Conveyor and Components. 8 pp. May-Fran Mfg. Co.

621 Seamless Mylar Belts. 4 pp. Kinelogic Corp.

624 Mechanical Differentials. 44 pp. Dynamic Gear Co.

717 Differential Gearing.* Specon differentials, differential transmissions. Two bulletins, 6 pp. Stratos Div., Industrial Products Branch, Fairchild Stratos Corp.

718 Linkage Joints.* For static or dynamic applications. Catalog 611, 4 pp. Link-Age Corp.

719 Universal Drive Tensioner.* With new bronze-bushed idlers. Bulletin 7161, 4 pp. Brewer Machine & Gear Co.

720 Conveyor-Belt Engineering.* Data for calculating, engineering, and selecting belts. Bulletin 175, 24 pp. Hewitt-Robins.

721 Shaft-Mounted Reducer.* TD025 unit for up to 1 hp at 90 rpm. Bulletin 602A, 4 pp. Dodge Mfg. Corp.

722 Chain Lubrication.* Of power-drive, elevator, and conveyor chains. Bulletin 1800, 8 pp. Oil-Rite Corp.

723 Ball and Roller Bearings.* Simple description of bearing parts and terms. Form 343, 24 pp. SKF Industries Inc.

724 Miniature Components.* Bearings, limit stops, slip clutches, gearing, shafts. Catalog 461, 18 pp. Northfield Precision Instrument Corp.

Assembly Components

602 One-Piece Fasteners. 32 pp. Tinnerman Products Inc.

611 Constant-Force Springs. 10 pp. Hunter Spring Co., Div., American Machine & Metals Inc.

725 Shock Absorbers.* Technical data, performance curves. "Shock and Vibration Control Equipment," 20 pp. Ellis Fluid Dynamics Corp.

Materials

609 Polycarbonate Resin. 6 pp. Chemical Materials Dept., General Electric Co.

613 Synthetic Fiber Felts. 8 pp. American Felt Co.

619 Metal Structural Material. 60 pp. International Steel Co.

629 Hollow Aluminum Stock. 12 pp. Aluminum Co. of America.

726 Metal-Braid Constructions.* Tubular and flat-metal types covered. Brochure TB301, 4 pp. National-Standard Co.

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728 Light Metals.* Magnesium, aluminum, titanium. 44 pp. Brooks & Perkins Inc.

729 High-Strength Steel.* Vascojet M-A has tensile strength above 360,000 psi. 20 pp. Vanadium-Alloys Steel Co.

730 Structural Damping.* Laminates for control of structural resonant response. Bulletin 719, 8 pp. Lord Mfg. Co.

731 Brasses and Tin-Brasses.* Six grades of brass wire, rod, strip. 6 pp. Riverside-Alloy Metal Div., H. K. Porter Co. Inc.

732 Bronze Parts.* Continucast process and alloys discussed. Bulletin JBL-36, 4 pp. Johnson Bronze Co.

HELPFUL LITERATURE (Cont.)

733 Small-Diameter Tubing.* To 1 in. OD size in various metals, alloys. Bulletin 13, 18 pp. Platinum Works, J. Bishop & Co.

734 Wire Cloth.* Plain, twill, Dutch, micronic, and special weaves. 16 pp. Unique Wire Weaving Co. Inc.

738 Brass Strip.* S-19 strip is scratch and dent-resistant. 4 pp. Chase Brass & Copper Co.

Engineering Dept. Equipment

736 Power Supplies.* Highly regulated dc units. Catalog P5961, 16 pp. Valor Instruments Inc.

737 Temperature Transducers.* Tanotherm interchangeable units discussed. Note 2342, 4 pp. Trans-Sonics Inc.

Circle the item number for information on products advertised or described, literature offered, and copies of editorial articles.

NEW PARTS, MATERIALS, ENGINEERING EQUIPMENT

Descriptions start on Page 188.

Electrical, Electronic

633 Gear motor develops up to 30 lb-in. torque. Merkle-Korff Gear Co.

635 Microminiature plugs have contact-center spacing of 0.05 in. Cannon Electric Co.

643 Battery holders accommodate popular zinc, mercury, or alkaline sizes. Augat Inc.

649 Right-angle gear motors in both ac and dc integral types. Westinghouse Electric Corp.

653 Synchronous motors for dc stepping duty. Superior Electric Co.

657 Microminiature resistors have range from 25 to 500,000 ohms. American Components Inc.

663 Subminiature switch is environment-free unit. Licon Div., Illinois Tool Works.

667 Miniature switch incorporates two snap-action units. Cherry Electrical Products Corp.

670 Carbon potentiometer operates at temperatures to 150 C. Trimpot Div., Bourns Inc.

673 Sealed potentiometer has wiper assembly within control knob. Clarostat Mfg. Co. Inc.

675 Wound-field motors are specifically wound for the application. Globe Industries Inc.

Hydraulic, Pneumatic

634 Flow regulator permits flow selection from 0.3 to 1.5 gpm. Fluid Regulators Corp.

639 Rotary bleeder valve for pressures to 500 psi. Greer Hydraulics Inc.

646 Hydraulic fittings in cross, tee, and elbow shapes. Fladar Corp.

647 Flexible connector conveys gas and fluids under temperatures to 750 F. Universal Metal Hose Co.

650 Square valves can be mounted in any of four 90-deg positions. Humphrey Products, Div., General Gas Light Co.

656 Ball and shuttle valves for air, water, or oil. Airmatic Valve Inc.

662 Hydraulic accumulators have built-in dashpot to eliminate piston shock. Taylor Devices Inc.

666 Solenoid valves for oil pressures to 3000 psi. Fluid Power Accessories Inc.

674 Liquid pumps for pressures to 3000 psi. Clevite Ordnance Div., Clevite Corp.

676 Plug valves have high-lubricity plastic coating on tapered surfaces. Meter & Valve Div., Rockwell Mfg. Co.

Mechanical Equipment

636 Miniature slip clutches provide constant torque transmission. Precision Specialties Inc.

641 Variable-speed pulleys have infinite speed range to 6:1. Rampe Mfg. Co.

645 Precision gears in 24 to 200 diametral pitch. Tech-Ohm Electronics Inc.

648 Reduction gear boxes in ¼ through ¾ hp. Sterling Electric Motors Inc.

652 Speed reducers in models with shafts extending up or down. Cleveland Worm & Gear Div., Eaton Mfg. Co.

658 Flange-type ball bearing for shaft diameters from ½ to 1 7/16 in. T. B. Wood's Sons Co.

659 Explosive cartridges meet pertinent military specifications. Hi-Shear Corp.

661 Overload safety unit is easily adjusted to maximum torque load. Dalton Gear Co.

678 Clutch-brake package for fhp duty-cycle use. Warner Electric Brake & Clutch Co.

Assembly Components

632 Counterbore set screw has extremely acute angle at point of entry. Standard Pressed Steel Co.

638 Garter springs have positive end connection. Associated Spring Corp.

644 Adhesive-backed nameplates have abrasion and corrosion-resistant surface. Aluminum Nameplate Corp.

651 Explosive bolt is fired by 0.6-amp current through protector. Ordnance Research & Development Co.

Materials

637 Chemical-resistant paint resists acetic, hydrochloric, and dilute sulfuric acids. Speco Inc.

640 Epoxy paper-base laminates for printed circuitry and terminal-board uses. Mica Corp.

642 Wire cloth of high-temperature, stainless-steel alloy. National-Standard Co.

654 Bearing bronze is self-lubricating, high-lead type. American Smelting & Refining Co.

655 Thin welded tubing in over 80 grades. Carpenter Steel Co.

660 Water-based adhesive bonds aluminum foil to paper, plastics, other surfaces. Rubba Inc.

664 Oil-resistant coating permits use of rubber on vibration mount. MB Electronics.

665 Acrylic sheet is tough, craze resistant. Rohm & Haas Co.

668 Modified polypropylene has high rigidity and heat-distortion values. Avisun Corp.

669 Magnet material has coercive force of 1400 oersteds. Indiana Steel Products Div., Indiana General Corp.

671 Acrylic molding powder has extremely high impact strength. Rohm & Haas Co.

672 Silicone rubber for use from −80 to +500 F temperatures. Dow Corning Corp.

677 Bondable fluorocarbons permit bond strengths to 55 lb per in. peel strength. Joclin Mfg.

679 Silicone-rubber base for temperatures from −120 to +450 F. Silicones Div., Union Carbide Corp.

680 Epoxy adhesive is two-part material which does not shrink or expand. Permacel Div., Johnson Inc.

681 Copper-clad laminate has high hot-peel strength. Synthane Corp.

Engineering Dept. Equipment

682 Electric pencil sharpener permits dialing of point width desired. Matsushita Electric Co. of America.

683 Laboratory feed pump has maximum capacity of 2½ gph. Whitey Research Tool Co.

684 Vacuum-tube voltmeter has individual scale for each range. B&K Mfg. Co.

685 Photocopy machine makes black-and-white copies from any color. Photorapid Corp.

686 Humidity meter has ±2 per cent accuracy. Telastat Corp.

687 Vibration-damping kit permits selection of over 15 damping effects. Electric Regulator Corp.

688 Servo voltmeter provides true potentiometric measurement of dc voltages. Houston Instrument Corp.

EDITORIAL ARTICLES

Single copies of the following articles are available as long as the supply lasts. Starred items are from previous issues. See Page 235 for other available reprints. Editorial content of MACHINE DESIGN is indexed in the Applied Science Technology Index and the Engineering Index, both available in libraries. Microfilm copies are available from University Microfilms, 313 N. First St., Ann Arbor, Mich.

22-1 Single Tire Replaces Duals. Major development in truck-tire design offers easier riding, better mobility and handling. (2 pp.)

22-2 Learning to Live with a Computer. Factors determining the success or failure of a computer installation. (6 pp.)

22-3 Purchased-Parts Drawings. Treating parts specification and identification details in contracts. (6 pp.)

22-4 Compression-Spring Design. Design methods, procedures, materials, allowable-stress data. (11 pp.)

22-5 Synthetic Hydraulic Fluids. Selecting fire-resistant hydraulic fluids: Characteristics, advantages, typical applications. (4 pp.)

22-6 Indicator Lights. Selection of light displays, based on human-engineering factors. (3 pp.)

22-7 Keeping Bolted Joints Tight. Avoiding decoupling of joints held together by threaded fasteners. (4 pp.)

22-8 Designing Minimum-Section Columns. Method for determining shape factors and optimum proportions of column sections under pure compression loading. (3 pp.)

22-9 Additives in Lubricants (Abstract). What they are and how they work. (4 pp.)

21-2 Value Engineering.* Setting up a program; pertinent recommendations. (5 pp.)

21-4 Cold Heading of Plastics.* Results of tests made to adapt cold heading of plastics to production-line fastening methods. (3 pp.)

21-5 Servovalves for Force Control.* Using servovalves for accurate control of force in hydraulic systems. (6 pp.)

21-7 Five-Bar Loop Synthesis.* Synthesizing the five-bar loop into mechanisms. (6 pp.)

21-10 Critical Speed of Shafts.* Nomogram for quickly finding critical speed of shafts. (3 pp.)

20-3 Gasket Loads.* Four techniques for evaluating flange pressure factors to improve flanged-joint design. (7 pp.)

20-9 Pin-Joint Design.* Nomograph design procedure for matching joint proportions to operating requirements. (4 pp.)

19-3 Statistical Dimensioning Program.* Setting up a program to improve the way assemblies function, while allowing all possible dimensional tolerance. (6 pp.)

19-5 High-Temperature Brazing Alloys.* Properties and applications of nickel-base brazing compositions for high-temperature metals. (4 pp.)

19-11 Quadratics-Cubics-Quartics.* Three methods, based on nomograms, to get quick, direct answers; procedure for refining roots to any degree of accuracy. (8 pp.)

18-2 Engineering and Research Reports.* Developing effective technical reports; seven most important kinds. (6 pp.)

18-3 Flame-Sprayed Coatings.* Four methods of flame-spraying protective coatings; guide to material selection, design of flame-sprayed parts. (11 pp.)

17-4 Critical Speeds of Coupled Machines.* Method for determining the critical speed, or natural lateral frequency, of an entire system. (7 pp.)

17-7 Radii of Gyration.* Nomograms for determining K^2 where multiple dimensions occur. (5 pp.)

16-5 Impact Loads.* Predicting effects of Suddenly applied loads; designing efficient structural parts. (9 pp.)

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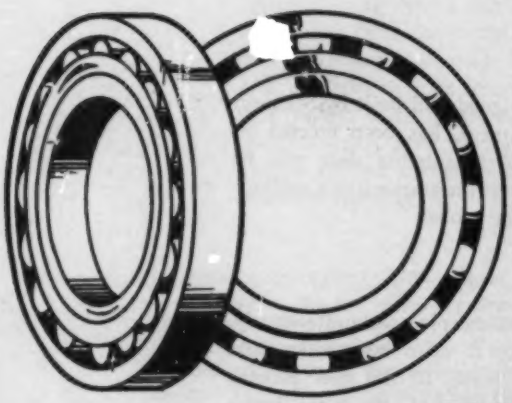
KAYDON NOW REDUCES PRICES ANOTHER 25% TO 42% FOR "CP" BALL RADIAL BEARINGS AVAILABLE "OFF-THE-SHELF"



Low prices are also being quoted on many other ball and roller bearings ...both standard (4" bore and larger) and special (2" bore and larger).

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Circle 213 on Page 19

trends

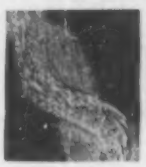
materials

Fire-Resistant Cloth Layers 'Welded' Together

A new process developed by Keasbey & Mattison Co., Ambler, Pa., bonds highly reflective aluminum foil and fire-resistant asbestos cloth in a manner described as producing a "welded" effect. The material, Kamklad, does not peel or crack; retains its shape after exposure to fire or water; and has higher resistance to heat and abrasion than conventional aluminized fire cloth. The solid aluminum barrier is 50 times thicker than the usual vapor-deposited protective layer. Kamklad passes the U. S. Air Force Glo Bar test at 2500 F.

A NEW PERMANENT MAGNET MATERIAL, possessing dimensional stability that is expected to increase timer motor reliability, soon will be used by Controls Co. of America in all its permanent-magnet motors. Lodex, molded in a lead matrix, has greater density than conventional magnets. It augments the flywheel effect and increases rotor torque. The new material was developed by General Electric Co.

CHARACTERISTICS OF FIBER GLASS that make it suitable for use in space vehicles may also provide the means of probing deep into the ocean, according to Aerojet-General Corp. scientists. Walls of a steel deep-sea submarine would have to be so thick that the sub would sink, they point out, but a glass-fiber filament-wound vessel could withstand maximum pressures and still be light enough to surface.



GRAPHITE CLOTH is being produced by National Carbon Co. Div. of Union Carbide Corp. Combined with plastic resins, the material will find uses in missile and rocket nose-cone and exhaust-nozzle components. A piece of the cloth, woven from one-ply graphite yarn, was molded into clear plastic then sliced down the center for examination under a microscope. A photomicrograph (left) showed 1440 filaments per twist, an important parameter in determining strength of the fabric.

GREATER MAGNETISM, toughness, and pliability are advantages of a new flexible magnetic gasket announced by B. F. Goodrich Industrial Products Co. The gasket has 40 per cent more magnetic power than the first Koroseal vinyl flexible magnets used as refrigerator door closures three years ago. It consists of an extruded Koroseal strip containing magnetized powder encased in a jacket of flexible Koroseal vinyl. The strip can be extruded in a variety of shapes and sizes and any length.

electronics

New Dish at Stanford

The largest radio telescope in the U. S., designed and built by Stanford Research Institute scientists for the government, has been erected on the Stanford University campus. The 150-ft antenna dish will be used with a 20-55 megacycle radio transmitter; the transmitter's million-watt input will generate a 300-400 kw radar probe.

Radar Pictures by Telephone

Rapid transmission of radar pictures to many places simultaneously, a procedure that is prohibitively expensive if video microwave links are used, is done via ordinary telephone lines. In the new process, called "slowed-down" video by Raytheon Canada Ltd., the radar signals are fed into a scan-converter which stores the information and converts it into a form usable on telephone lines. Information sent is revised once every 40 seconds, whereas the image fed into the scan-converter is updated about every 10 seconds. A typical application is passing along air-traffic monitoring of an airplane from one control center to the next.

PROFESSIONAL STATUS, in the eyes of the National Labor Relations Board, is becoming increasingly dependent upon a bachelor's degree. This is the observation of the National Society of Professional Engineers, which has noted that NLRB decisions rely on engineers' educational background in rulings to determine appropriate collective bargaining voting units. An NSPE publication, The Engineer in Industry in the 1960s, says, "Perhaps this is an indication of an increasing national trend to require graduation from college as a prerequisite for recognized professional status."

ENGINEERS WORKING on faculties and staffs of colleges and universities numbered 25,500 in 1958, according to a preliminary report of a survey by the National Science Foundation. Of this total, 15,100 were faculty members, and 10,400 were nonfaculty. Over 12,000 spent some time in research and development activities—4800 of the faculty engineers, and 7600 of the nonfaculty engineers. Part of NSF's program to count all engineering and scientific personnel, the college census resulted from a canvass of 1916 institutions, 1480 of which supplied usable information.

RADIOISOTOPES, x-rays, and electrical conductivity will be employed in research by SKF Industries, Philadelphia, to learn how lubrication affects life of bearings expected to operate reliably in adverse surroundings. In a three-year study for the Navy, different types of lubricants will be tested to learn their characteristics in highly stressed areas between bearing rolling elements and races.

R & D CONTRACTS can be profitable, when the work adds to company prestige, employs personnel who will be needed in the future, or pays for research applicable to other products. Adm. S. B. Spangler, director of research of the Garrett Corp., told this to American Management Association members. He also warned against making research proposals without people or facilities to do the job.

Pushbuttons Bring the Big Board to Brokers' Desks

An electronic computer system that puts up-to-the-minute stock market figures at the fingertips of brokers has been introduced by Ultronic Systems Corp., Pennsauken, N. J. The SDP-4000 system consists of individual desk units connected to computer and communications equipment that collects and processes information and stores it in a memory unit. After dialing the code for one of 4000 stocks, the user can push buttons that provide price (high and low for the day and closing price for the previous day), last price and time of last transaction, bid and asked figures, volume traded, number of trades, and the company's last four quarterly earnings.

HYDROSTATIC EXTRUSION—without direct contact between ram and billet—is accomplished in a new method developed by the National Engineering Laboratory of the Dept. of Scientific and Industrial Research, East Kilbride, Glasgow, Scotland. Extrusions with more uniform mechanical properties are produced, and pressures are 30 to 40 per cent lower than in conventional processes. A billet shaped to fit a conical die produces a seal at the die face, permitting generation of fluid pressures above and around the billet and thus eliminating container friction. So far, aluminum and its alloys have been extruded; use of steels is being investigated.

MAJOR PLASTICS PROCESSES, including blow molding, injection molding, and reinforced polyesters, are being investigated by Arthur D. Little Inc., Cambridge, Mass. The study—believed to be the most comprehensive investigation of the plastic field ever undertaken—will compare investment and production requirements of the processes. Cost information developed will aid management of participating companies in deciding whether to set up internal plastics production facilities or buy from outside sources. Other phases of the seven-month project will provide information to design and process development groups and engineering departments.

Performance Up, Weight Down In One-for-Two Wheel Swap

Single Oval

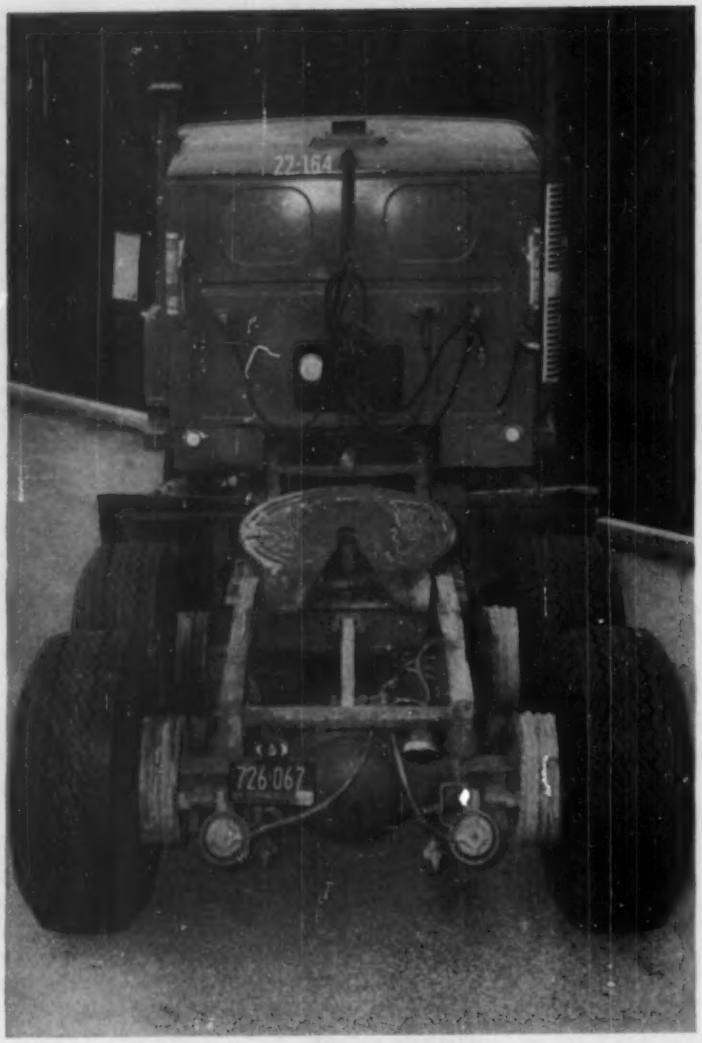
A MAJOR development in truck-tire design has quietly been making inroads on the conventional dual-wheel setup. The new concept—use of single oval tires in place of duals—was described at the recent SAE Heavy Duty Vehicle Meeting in Milwaukee by R. P. Powers, Firestone Tire & Rubber Co.

According to Powers, Firestone's interest in a single oval tire, called the Duplex, stems back to experimental work conducted early in 1960. Original purpose of the Duplex project: To determine whether a tire must necessarily be as high as it is wide in order to have sufficient flex life for the millions of cycles to which it would be subjected in normal trucking service. Little background on oval tires was available. Some passenger car and airplane tires with section height/width ratios in the range of 80 to 85 per cent had been built, but there was a shortage of information on lower section heights.

Oval Gets an O.K.

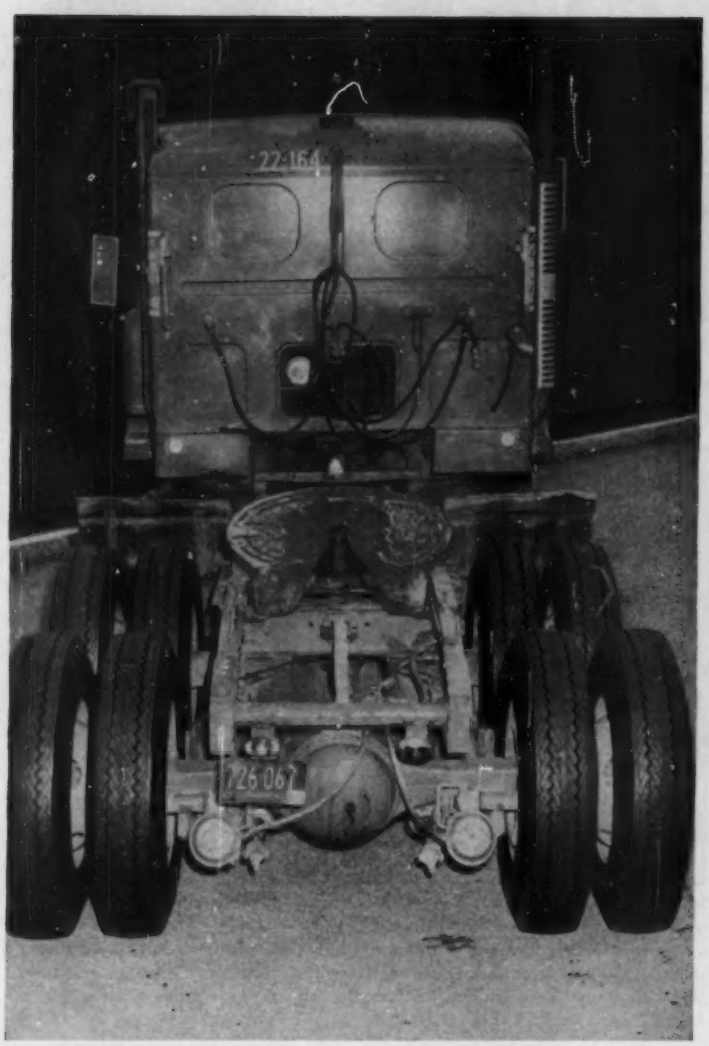
Taking stress measurement on individual cords in the new oval tire, Firestone engineers found that less cord compression was present in the low section-height tire during rotation under load than in conventional tires. Endurance tests on the road substantiated the conclusion that there was no flex weakness. Actual tests by commercial truck lines followed. Favorable reaction by the first users during the past year has prompted considerable demand for the new tire. Several advantages of the Duplex were never initially anticipated:

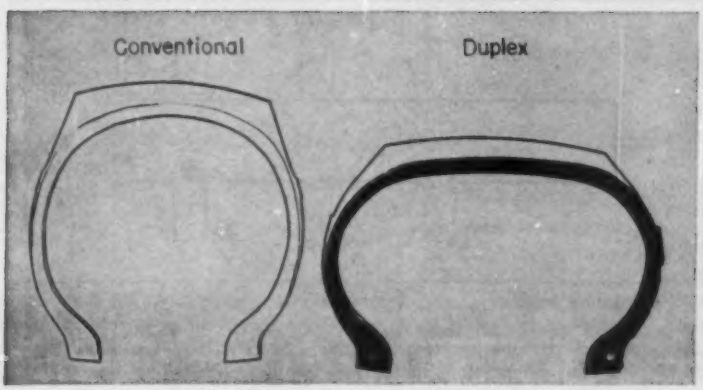
- **Easier riding**—Two side walls in place of four results in a softer ride for the operator, less shock and wear on the vehicle. This should have a favorable effect on maintenance costs.
- **Increased off-road mobility**—Traction advantages of a large single tire over duals is commonly recognized, and is particularly significant in sand and soft soil.
- **Better handling on curves**—This apparently arises from road unevenness; the load is constantly shifting from one dual to the other, permitting some creep. The Duplex, carrying all the load, gets

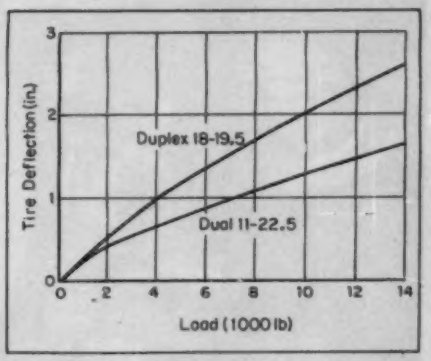


Most truck tires are almost round; the 14.00-20 (right) has a section height/width ratio of 95-100 per cent, which is fairly common. When the same tire section, less tread and sidewall, is made oval and wider tread is added, a section height/width ratio of 63 per cent is obtained (periphery has not changed). The 14.00-20 thus becomes an 18-19.5. Diameter of the finished 18-19.5 is 42.9 in. compared to 41.6 in. for the duals. But because the oval tires deflect further under load, rolling radii of the two tires are almost identical. The tire and wheel assemblies are interchangeable on the proper axles.

Tires Replace Duals







Easier ride of Duplex tires is evident from load deflection curves. Comparison is between 10.00-20 duals and 18-19.5 Duplex; duals have a spring rate of 10,700 lb per in. of deflection compared to 6600 lb for the Duplex. Resulting reduction in shock and vibration should decrease maintenance.

a better grip on the road surface, even allows cornering at slightly higher speed.

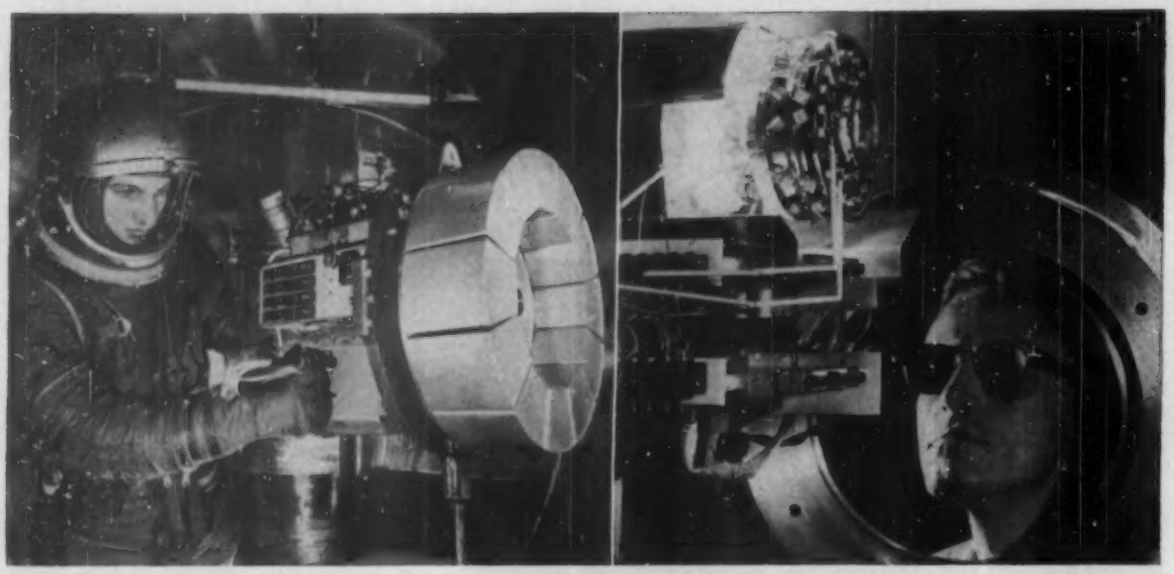
• **Lighter weight**—The following table shows that the Duplex tire-and-wheel assembly can provide weight savings of 176 to 304 lb per axle over duals. This means more payload.

Part	Regular Duals (11-22.5)	(10.00-20)	Duplex (18-19.5)
Tire Assembly (lb)	252	258	192
Disc Wheel (lb)	136	194	108
Total (lb)	388	452	300

• **Better brake service** — Exposing the drums to more air circulation (picture, left) contributes to more effective braking and longer brake life.

In addition to these advantages, there are others which would apply to new vehicle design, such as permitting wider spring spacing. Also, because the Duplex tire is essentially the same diameter as the duals it would replace, use of it on front wheels of properly designed trucks would permit higher front-axle loads without going to large-diameter singles or excessively high air pressure in standard sizes.

Duplex tires can also be used in small-diameter sizes with greater load capacity than is now possible with conventional tires of corresponding diameters. It is also reasonable to assume that there will be some places where they might be used as duals themselves.



Republic's Plasma Engine **Hughes' Ion Engine**

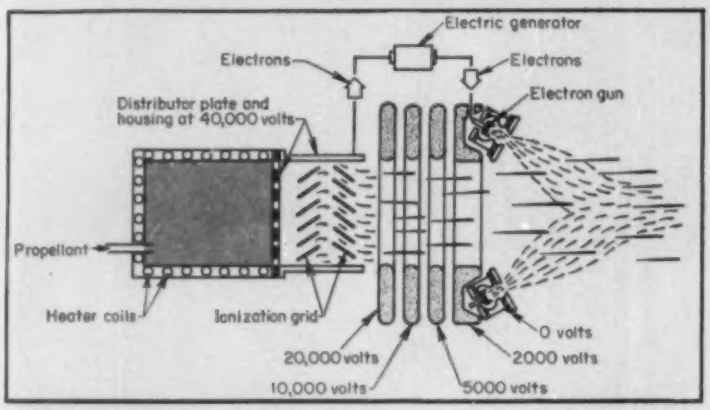
Flight Tests Near for Electric Space Engines

TWO major aerospace companies —Hughes Aircraft Co. and Republic Aviation Corp.—will have prototype electric space engines ready for flight testing by next year.

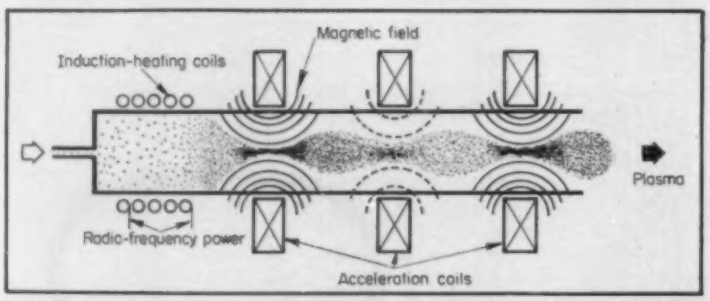
Republic's plasma engine is described by company officials as being the ideal acceleration system for changing a satellite's orbital path and to perform other delicate rendezvous and attitude-control functions. It will operate for months or years in space, powered by batteries and solar cells (output of a 28-v battery is upped to 3000 v). Weight of the plasma engine is about 150 lb, its length and diameter both measure about 20 in.

Hughes' ion engine, being developed in co-operation with NASA, is called the ultimate power source for deep-space propulsion. It will probably be used in the first interplanetary probes aimed at Mars and Venus. The engine will be powered by a nuclear reactor.

According to Dr. Ernest Stuhlinger, director of NASA's Marshall Research Projects Div., an ion-propelled spacecraft capable of traveling from Mars to Earth and back could be built with a useful payload on the order of 50 per cent of its total initial mass. It would have a travel time nearly equal to that of a spacecraft with a chemical or nuclear powerplant.



Typical ion engine . . . strips electrons from an entering propellant (such as cesium) with a very hot ionization grid. Positively charged to 40,000 v, the grid repels the ions, attracts the electrons. Other positively charged rings accelerate propellant ions through the nozzle at velocities reaching 500,000 mph. Specific-impulse for the ion engine ranges from 4000 to 10,000 sec.



Typical plasma engine . . . accelerates charged particles with a magnetic field. Propellant is heated by a radio-frequency field or an electric arc before ejection by the acceleration coils. Specific impulses as high as 25,000 sec may be possible for plasma engines.

TO THE CREATIVE DESIGNER...

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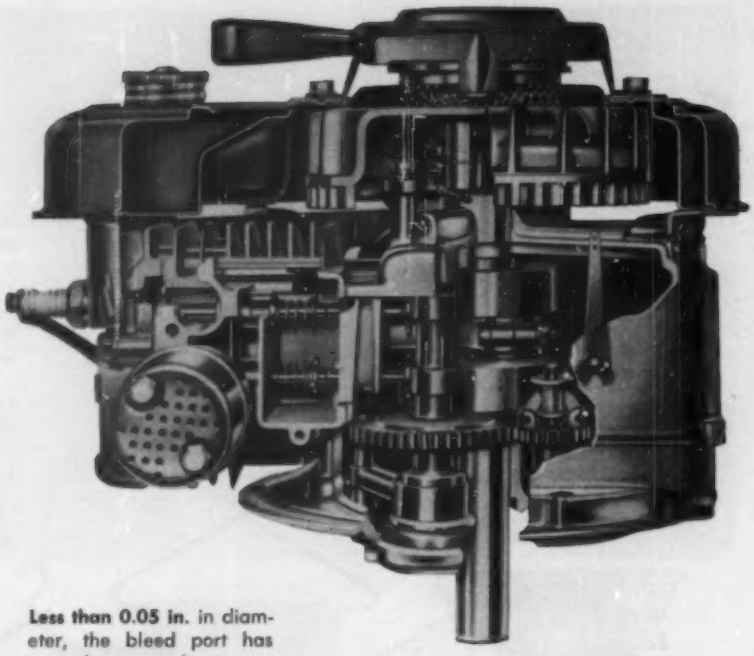
Circle 214 on Page 19

Bleed Port, Foil Coil Beat Hard Start In Small Engines



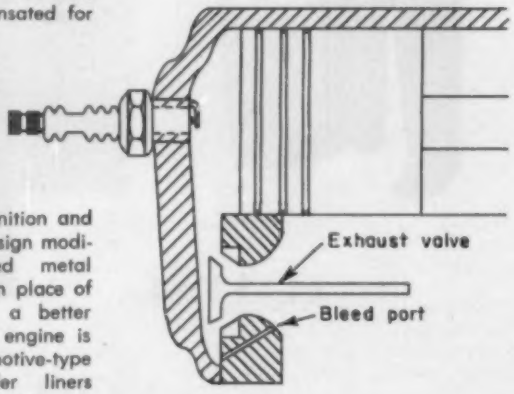
THE idea is relatively simple—a bleed port between cylinder and exhaust manifold will reduce compression in an ordinary four-cycle engine, making it easier to crank.

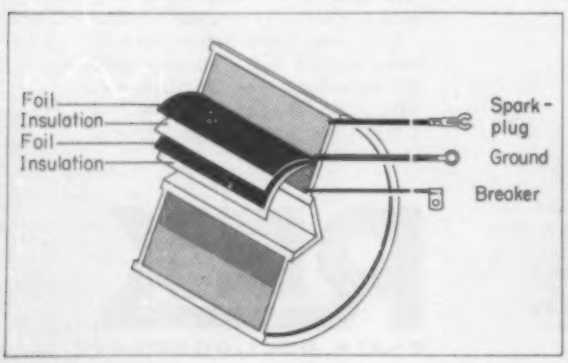
This was the starting point for a basic refinement in small four-cycle engines achieved by engineers at Tecumseh Products Co., Tecumseh, Mich. Motivating force behind the project was a desire to make the home lawn mower completely wife startable.

In deciding on the bleed-port principle, Tecumseh engineers were faced with an obvious problem—loss of initial compression (and bleed-off of some fuel) had an unfavorable effect on combustion, particularly at engine-cranking speed. They solved this by designing a hotter ignition.

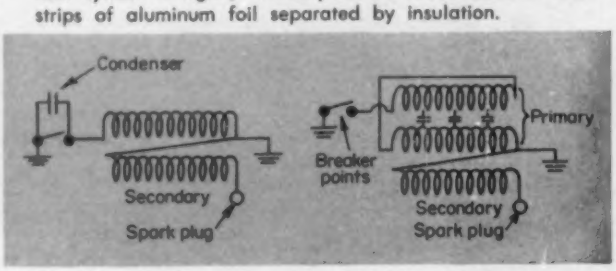
The effect of the bleed port on cranking effort is significant: Spring-scale tests show that the new engine requires half as much muscle power as previous models. With the hotter ignition, it starts easily at a cranking speed of 175 rpm vs. a minimum speed of 350 rpm for previous models.

Less than 0.05 in. in diameter, the bleed port has caused no penalty in engine performance. In fact, better performance is claimed by Tecumseh. Power output would ordinarily suffer, from porting effect, but this has been overcompensated for by the hotter ignition and by two other design modifications: Lipped metal gasket is used in place of fiber to insure a better head seal; the engine is fitted with automotive-type cast-iron cylinder liners which reduce friction to below normal for comparable four-cycle engines.





Equivalent capacitance in the coil effectively replaces a separate condenser in the new Tecumseh ignition system. (Schematics, below, show conventional ignition at left, the new system at right.) Primary of the coil consists of two strips of aluminum foil separated by insulation.



CLIMAX MOLYBDENUM

Molysulfide® News Digest

CLIMAX MOLYBDENUM COMPANY, a division of American Metal Climax, Inc., 1270 Avenue of the Americas, New York 20, N.Y.

EDITORIAL PAGES OF LEADING TRADE MAGAZINES FEATURE MoS_2 INFORMATION

Higher temperatures, lower temperatures, greater pressures, longer lubrication life, all have combined to focus more attention on the uncommon lubricating values of molybdenum disulphide.

That's why editors are devoting more and more space to descriptions of what MoS_2 can and cannot do.

One article tells how MoS_2 prevents harmful friction in brake linings. Another discusses its use as a compressor lube substitute. Still another reports on tests of epoxy-resin compositions containing high concentrations of MoS_2 for industrial use on bearings, seals and friction strips.

Press fittings, wire drawing, cutting tools, ball joints—there are MoS_2 stories about these uses, too.

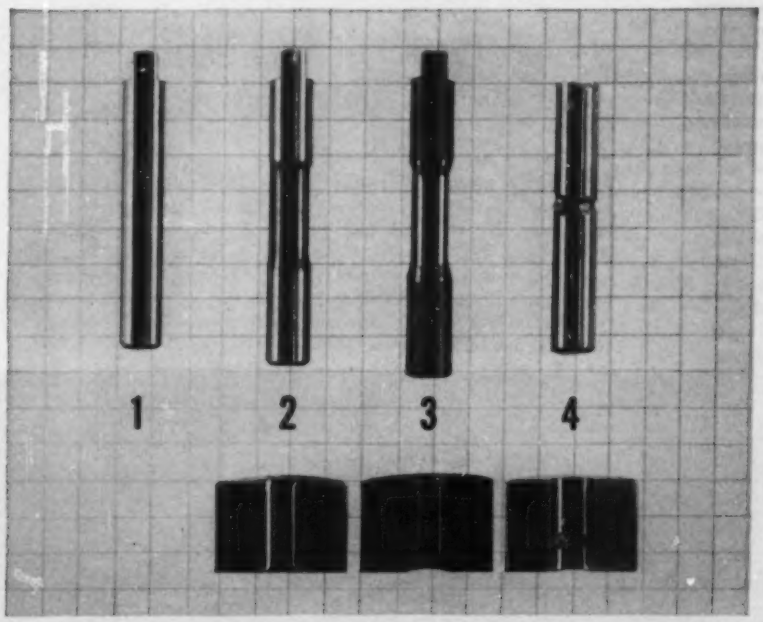
MoS_2 as a solid-film dry lubricant has been the subject of several articles. One details high-temperature properties; another describes a new bearing design that can increase bearing life as much as 450%.

Write us for a complete bibliography of published material on molybdenum disulphide.

P.S. Climax publishes a newsletter that describes even more uses. Let us know if you'd like your name on the mailing list.

Circle 215 on Page 19

Proof of MoS_2's High-Pressure Properties



Photograph above shows mild steel test pins. No. 1: Unused pin, No. 2 (lubricated with mineral oil and Molysulfide) and No. 3 (with Molysulfide bonded coating) were subjected to rotating pressures between bearing halves. Both were elongated and extruded without galling, seizing, or weight loss. No. 4 shows typical failure with conventional lubricant. Note that the key sheared off and pin and block were galled and seized.

Circle 217 on Page 19

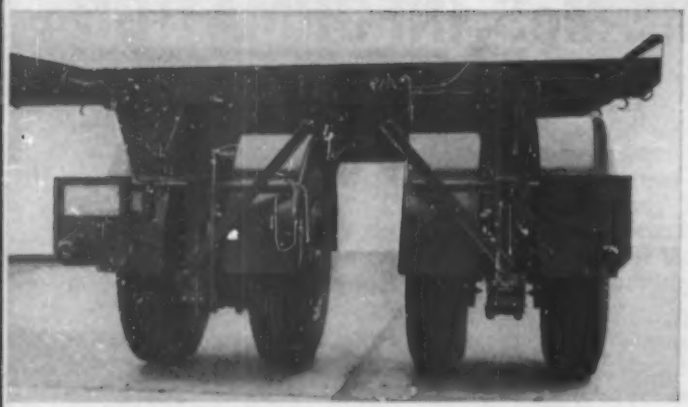
ASME SHOW DEVOTES SESSION TO "MOLY" LUBES

New evidence of mounting interest in molybdenum disulphide was shown recently among members of the American Society of Mechanical Engineers. A spokesman for the Climax Chemical Division was invited to speak on "Molybdenum Disulphide as a Lubricant" before the Machine Design Division at the 1961 Design Engineering Conference. A copy of this 24-page paper is available on request.

At the same meeting, engineers from Socony Mobil Oil Company spoke on "Molybdenum Disulphide as an Additive to Improve the Performance of an Automotive Multi-purpose Grease." Write to Climax for a copy of this paper.

Circle 216 on Page 19

Fallout shelter designed by the Kelsey-Hayes Co. (Heintz Div., Philadelphia) can be erected in a basement in less than 24 hours. The shelter is of modular design, and basic size is 9 by 9 ft. Self-supporting, it is a series of sheet-metal panels which are bolted together, then filled with earth or sand. It is accepted by the Office of Civil and Defense Mobilization



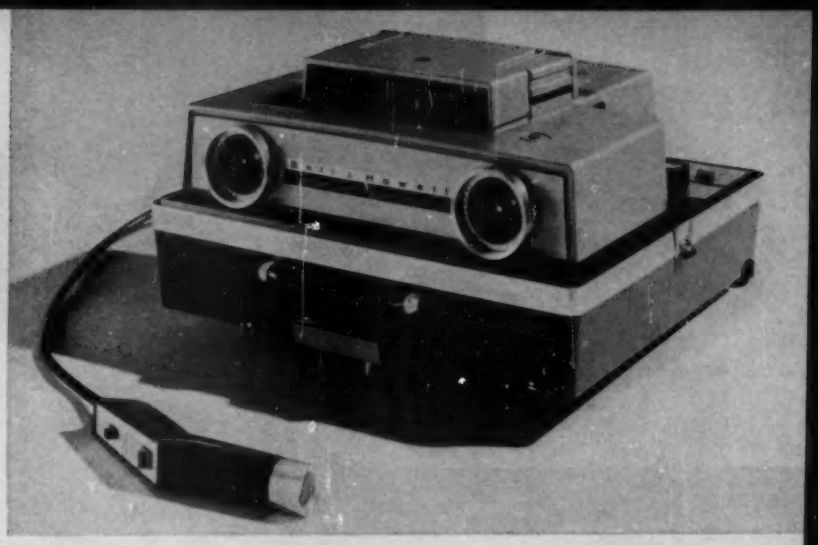
Two short axles, independently suspended, form an unusual running-gear layout on Fourtrak, a 15-ton semitrailer introduced by Scammell Lorries Ltd., Leyland Motors Ltd., Leyland, Lanchashire, England. Advantages include use of four tires instead of the eight required on tandem-axle trailers; elimination of tire scrubbing, since each wheel rotates independently; and equal loading of tires, which are all always in contact with the road.

Miniature recorder makes a permanent paper-tape record of any variable (such as voltage, current, power, temperature, pressure) that can be converted to an equivalent electrical signal. It can be used as either a portable monitoring and recording device or as a built-in component of an instrument system. Two basic meter movements (internal-core D'Arsonval and rectified D'Arsonval) measure a wide range of dc and ac quantites without amplification. The recorder, made by Amprobe Instrument Corp., Lynbrook, N. Y., is available in a number of versions, each in several ranges.

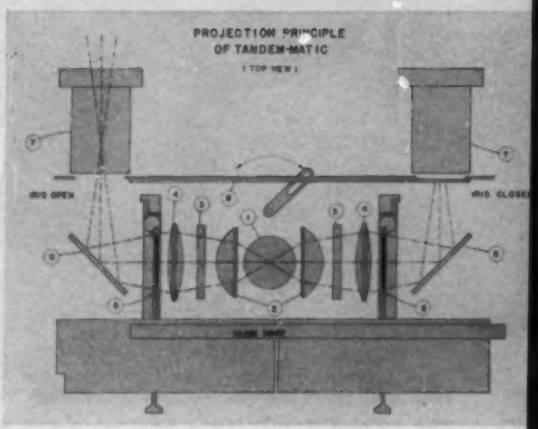
Four fully powered tracks take Dinah, a half-ton articulated carrier, on scouting, reconnaissance, and hauling missions across inland waters as well as on land. Power comes from a two-cylinder, 50-hp engine (the outboard is used just for testing), and steering is by means of the hydraulic Polecat Joint between the two halves. More mobile than the M29-C Weasel, Dinah is intended to replace the older vehicle. It was developed by Wilson, Nuttall, Raimond Engineers Inc., Chestertown, Md.

ENGINEERING NEWS

PICTURE REPORT



A pair of synchronized irises in the Tandem-Matic slide projector's double optical system produces a lap-dissolve effect. Simultaneous fading out of one slide and fading in of the next takes 1½ seconds. This action—used with shots in which only certain elements have been changed—can produce the effect of a motion picture. Key components of the projector are two 5-in., f/3.5 lenses which are focused on the same spot on the screen. .Operation is shown in the drawing: Light (dashed lines) is thrown by 750-w lamp (1) through first condenser (2), heat filter (3), and second condenser (4), projecting image of slide (5) onto 45-deg mirror (6), which reflects picture through lens (7). Sliding iris blade (8) gradually opens the right lens and closes the left one, producing the lap-dissolve effect. Bell & Howell Co., Chicago, makes the Tandem-Matic.

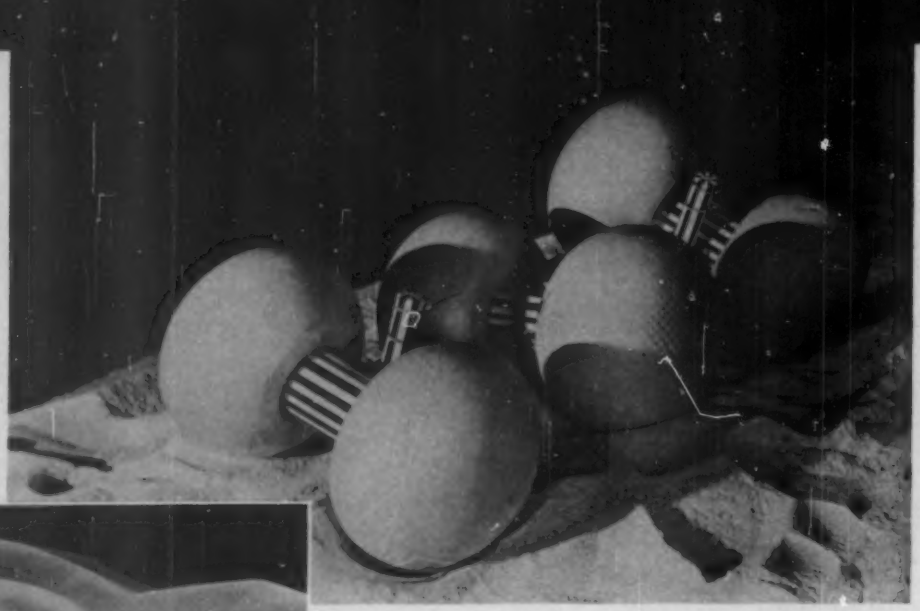


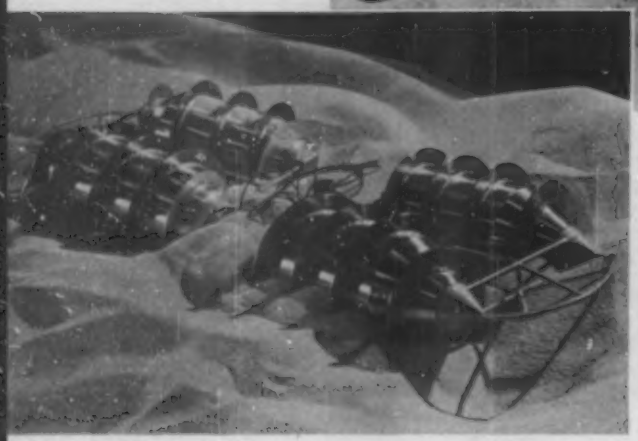
Battery capacity is fully utilized in the new electric Transitruck built by Smith's Delivery Vehicles Ltd., Gateshead on Tyne, England. The truck has a transistorized semiconductor method of control (using silicon controlled rectifiers) which gives stepless, smooth operation from idle to top speed. Reduction in voltage for starting is attained by using silicon controlled rectifiers in conjuction with a transistor oscillator to rapidly make and break the circuit, thus reducing the mean applied voltage. The Smith truck also carries its own miniaturized, electronic charging equipment. The charger does not need a transformer, because necessary voltage transformation is obtained by phase-firing a silicon controlled rectifier.

Wheels,

Tracks,

or Screws?





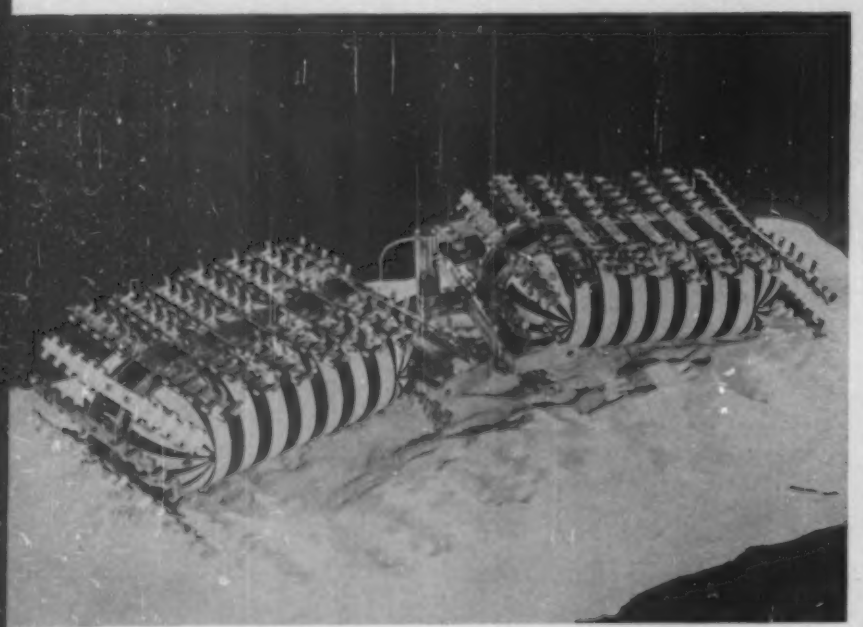
Three basic means of vehicle locomotion are being examined for lunar use by GM engineers. Three-axle transporter with nearly spherical wheels would excel on irregular terrain; multiscrew configuration could worm through loose or fluffy soil, even if completely buried; tracked vehicle, with tracks encircling the body, would perform well on either soft or hard soil. All vehicles are electrically powered.

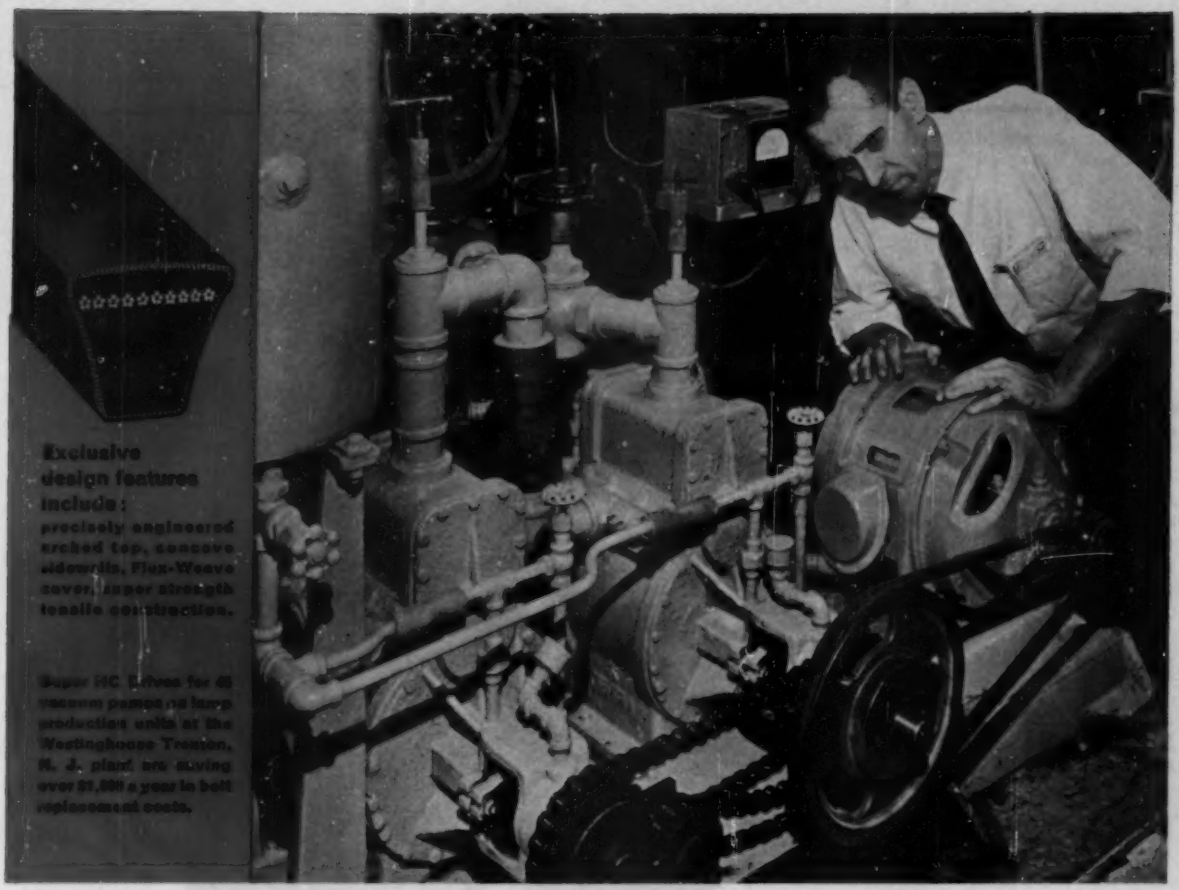
Designers Sift Moon-Mobility Methods

ROVING lunar surface vehicles are being investigated by a growing number of companies now that the U.S. space program is nearing the point of putting unmanned probes on the moon. All current studies are obviously subject to drastic change as more information becomes available on the lunar-surface environment. The one basic unknown: Composition of the moon's surface—is it rocky, dusty, hard, or soft; are slopes few or far between, steep or rolling? Despite the speculation, designers are making use of available information to design a series of unearthly vehicles.

Typical of preliminary projects is one at General Motors' Defense Systems Div. As a means of locomotion for their lunar bus, GM scientists are considering wheels, tracks, and even an assembly of Archimedes screws. Low-pressure rollers are also in the running. In contrast to these rather conventional methods of mobility, walking devices are being touted by other design teams. The walking machine can be made with high efficiency, performing work only in compacting the surface at intervals, and legs can easily be folded to fit into a nose cone.

Control of the lunar rover poses one of the more difficult problems. The vehicle will undoubtedly be equipped with TV scanners and controlled from earth. Transmission delay of radio waves will amount to 3 seconds; other factors, including vehicle travel speed (up to 5 mph), will mean a considerable lag between command and reaction. The vehicle will travel 20 to 30 ft in the time it takes for a command to be issued and the operator sees it activated.




Exclusive design features include:
precisely engineered arched top, concave sidewalls, Flex-Weave cover, super strength tensile construction.

Westinghouse converts drives on 45 machines to new Gates Super HC High Capacity V-Belts

When drive space is limited, a driver sheave too small in diameter is sometimes used—though not recommended. Constant flexing over a small sheave is severe punishment for V-belts. Because of this, conventional V-belts lasted 4 months or less on the vacuum pumps on lamp production units at the Westinghouse Lamp Division plant in Trenton, N.J.

Now, with space-saving Gates Super HC High Capacity V-Belt Drives on all 45 machines, all belts are still running strong after more than 1½ years . . . a saving of over $1,000 in belt replacement costs plus even greater savings through reduced down-time.

The Gates Super High Capacity V-Belt is a new concept in V-belt design.

It is industry's first and most advanced high capacity V-belt. Because of exclusive design features, Gates Super High Capacity V-Belts transmit up to 3 times more horsepower than conventional V-belts in the same space. Or the same power can be handled with fewer belts and smaller sheaves in less space.

As a result, Gates Super HC Drives save up to 50% in drive space . . . cut your drive costs as much as 20% . . . reduce drive weight 20% and more . . . and make possible further savings in material costs.

Your local Gates Field Engineer is an experienced, fully-qualified drive design expert. Contact him for Super HC design information and for design help.

Building the future on 50 years of progress

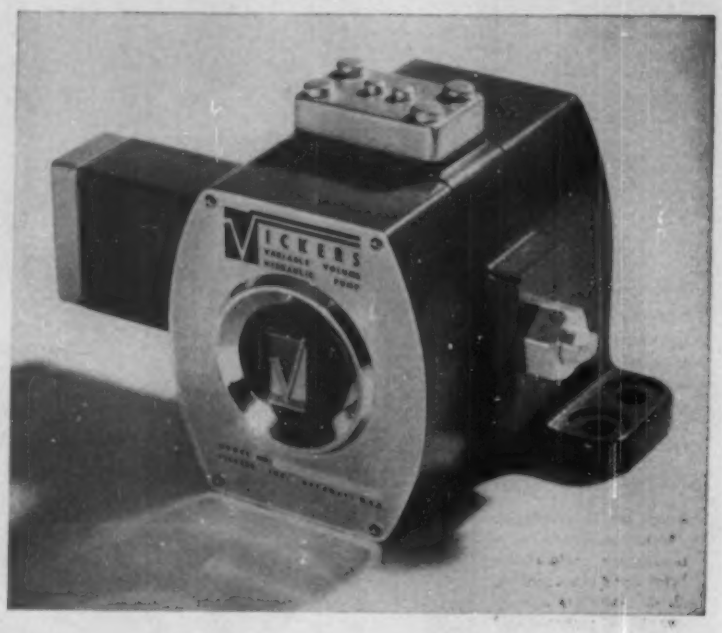
The Gates Rubber Company, Denver, Colorado SP4D

Gates Super HC V-Belt Drives

Industrial Design

comments and configurations

Carl W. Sundberg and Montgomery Ferar—industrial designers whose firm designs more appliances than any other in the U. S.—have made the statement, "Competitive-minded firms are using a new tool to improve products, make them more salable, and help reduce manufacturing costs. This 'tool,' still unknown to a large segment of industry, is the industrial designer." Sundberg and Ferar, their seven associates, and staff of 50 also use a number of tools in their work. Manipulation of a basic and important one—materials—is illustrated in this group of recent Sundberg-Ferar designs.



Variable-volume hydraulic pump, designed for Vickers Inc., uses sandwiched cast parts.

Kenmore die-cast aluminum canister vacuum cleaner was designed for Whirlpool Corp.

The Flying Scott (McCulloch Corp.) has a fiber glass hull, plexiglass tilt-up windshield, Dacron and Orlon convertible top.

Starfire portable typewriter, designed for Remington Rand Corp., is covered by an impact-resistant Cycolac case.

"The battle of materials can be roughly divided into a competition between three groups: Steel, aluminum, and plastics. Since designers are a kind of clearinghouse for new ideas, we are deluged daily with information about new materials and ideas from all three of these industries—and we welcome this. . . .

"There is a tendency to oversell, and because of their enthusiasm about the virtues of their material, some manufacturers are apt to recommend applications that could be harmful to their own cause. Some of the kickbacks caused by this approach take a long time to live down. . . . If a material supplier runs a risk of forcing his product by one means or another into an application that it is not suited for, you may be sure of several things. The business that he gains will be of a very temporary nature, but the harmful effects even on future business that the material is qualified for will be of a more permanent nature.

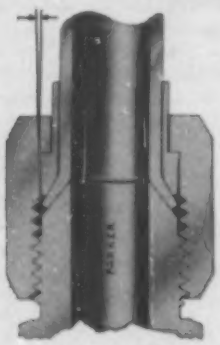
"You may also be sure that the weakness of the offending material will be given plenty of free publicity by competition. Your own industry has experienced this type of playback, and much of the criticism that we receive today about the use of plastics is a hangover from the days when plastics were recommended and used in applications for which suitable materials were not yet available. As a result of this, today many of your good new materials are not receiving the proper consideration. The American consumer has a long memory concerning product failure."

—CARL W. SUNDBERG

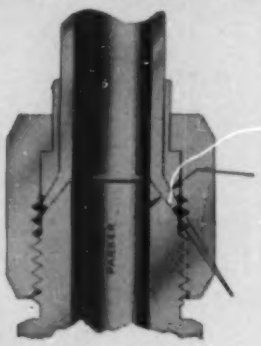
in a talk before the Society of the Plastics Industries

Washer-dryer (Kenmore, for Whirlpool) uses colored plastic pushbuttons on a black background.

PARKER "TRIPLE-LOK®" 37° FLARE FITTINGS GIVE YOU THE QUALITY YOU NEED AT EVERY CRITICAL POINT!!!



A tiny Reverse Clearance Angle makes the Parker sleeve act as a lockwasher. Sleeve shoulder exerts pressure back against nut to prevent loosening from vibration, or from expansion and contraction.



The precise Differential Angle between sleeve and nose gives you perfect surface contact, maximum sealing and even distribution of make-up loads. It compensates for natural thinning of the flare.

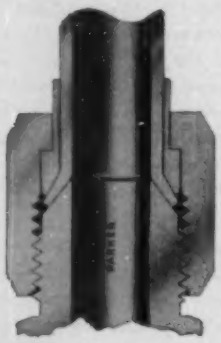
PARKER WORKMANSHIP PAYS OFF FOR YOU IN ASSEMBLY AND USE

The fact that Parker developed the original 37° flare fitting is only part of the story. At Parker today, infinite attention to detail is your assurance that you will get all the plus values inherent in the original Parker design.

Illustrated here are only four of the many critical points which Parker watches in making "Triple-lok," the 37° flare fittings that bear the Parker name. Tiny variations from the angles and clearances to which Parker craftsmen work can mean the difference between the maximum protection you get from the Parker product and something much less dependable. A Parker-Hannifin distributor is as near you as your telephone. Check the Yellow Pages, or write us direct.

Fittings shapes are machined from high-strength, one-piece forgings. No cast, extruded or brazed construction. The finer grain structure of forgings provides higher tensile strength and a greater elongation factor.

"Triple-lok" parts can be used repeatedly . . . are never deformed in make-up nor wedged on to tubing. Sleeve never rotates during assembly . . . no danger of wiping or scoring tube flare.



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Meetings and Shows

Oct. 30-31—

Institute of Radio Engineers — Electronic Industries Association. Radio Fall Meetings to be held at the Hotel Syracuse, Syracuse, N. Y. Additional information is available from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

Nov. 1-3—

Society for Experimental Stress Analysis. First International Congress on Experimental Mechanics to be held at the Hotel New Yorker, New York. Papers will cover experimental stress analysis and other areas of experimental mechanics, and there will be a display of latest equipment and instrumentation used in the field. Additional information can be obtained from SESA headquarters, 21 Bridge Square, Westport, Conn.

Nov. 6-8—

American Documentation Institute. Annual Convention to be held at the Somerset Hotel, Boston. Further information is available from P. D. Vachon, Literature Physicist, Melpar Inc., Applied Science Div., 11 Galen St., Watertown 72, Mass.

Nov. 6-10—

American Nuclear Society. Annual Meeting, to be held in conjunction with the Atomic Industrial Forum, AtomFair, and the National Youth Conference on the Atom, at the Conrad Hilton Hotel, Chicago. Additional information can be obtained from society headquarters, 86 E. Randolph St., Chicago 1, Ill.

Nov. 7-10 —

Packaging Machinery Manufacturers Institute Show to be held at Cobo Hall, Detroit. The Conference-Workshop will be held Nov. 8 and 9. Further information is available from the show manager, Shea Expositions Corp., 1 Gateway Center, Pittsburgh 22, Pa.

Nov. 9-10—

Society of Automotive Engineers Inc. Fuels and Lubricants Meeting to be held at the Shamrock Hotel, Houston, Texas. Further information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Nov. 13-15—

Steel Founders' Society of America. Technical and Operating Conference to be held at the Hotel Carter, Cleveland. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

Nov. 13-16—

Seventh Annual International Conference on Magnetism and Magnetic Materials to be held at the Westward Ho Hotel, Phoenix. Sponsors are American Institute of Electrical Engineers and American Institute of Physics, in co-operation with the Office of Naval Research, Institute of Radio Engineers, and Metallurgical Society of the AIME. Further information is available from Dr. P. B. Myers, Motorola Inc., 5005 E. McDowell Rd., Phoenix 8, Ariz.

Nov. 15-17—

Aerospace Electrical Society. Annual Display to be held at the Pan Pacific Auditorium, Los Angeles. Additional information is available from Norman Lynn, 1830 W. Olympic Blvd., Los Angeles 6, Calif.

Nov. 15-18—

Society of Naval Architects and Marine Engineers. Annual Meeting to be held at the Waldorf-Astoria Hotel, New York. Further information is available from SNAME headquarters, 74 Trinity Place, New York 6, N. Y.

Nov. 16—

National Electrical Manufacturers Association. 35th Annual Meeting to be held at the Plaza Hotel, New York. Further information can be obtained from NEMA headquarters, 155 E. 44th St., New York 17, N. Y.

Nov. 20-21—

Institute of Radio Engineers. Electron Devices Meeting to be held at the Shoreham Hotel, Washington,

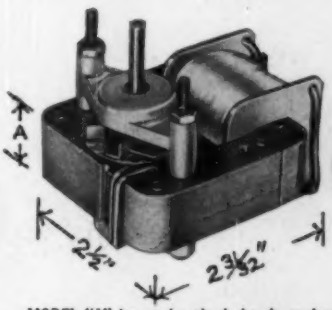
(*Please turn to Page 40*)

GENERAL INDUSTRIES

SMOOTH POWER

AC MOTORS

offer unmatched quality and dependability yet cost no more—often less!



MODEL "A" two pole, shaded pole motor available in various lamination thicknesses. Precision constructed for reliable, long hard usage. Perfectly balanced for smooth quiet operation.

MODEL	HP 3800 RPM	Locked Torque in./oz.	Max. Torque in./oz.	Free Speed RPM	A
A-3-CW A-3-CCW	1/450	0.7	1.1	3360	3/8"
A-5-CW A-5-CCW	1/170	1.8	2.3	3430	5/8"
A-6-CW A-6-CCW	1/130	2.2	2.9	3470	3/4"
A-7-CW A-7-CCW	1/100	2.5	3.4	3480	7/8"
A-8-CW A-8-CCW	1/80	3.2	4.5	3480	1"
A-9-CW A-9-CCW	1/70	3.7	5.3	3480	1 1/8"
A-12-CW A-12-CCW	1/60	4.5	6.5	3500	1 1/2"
A-14-CW A-14-CCW	1/50	5.0	7.0	3490	1 3/4"

Standard shaft diameter .1817, 1/4" shaft available if desired.

Standard Line From 1/1800 to 1/35 H.P.

See Our Catalog in SWEETS 7a-Gen (S) or write for copy

Quantity Price Quotation On Request

THE GENERAL INDUSTRIES CO.

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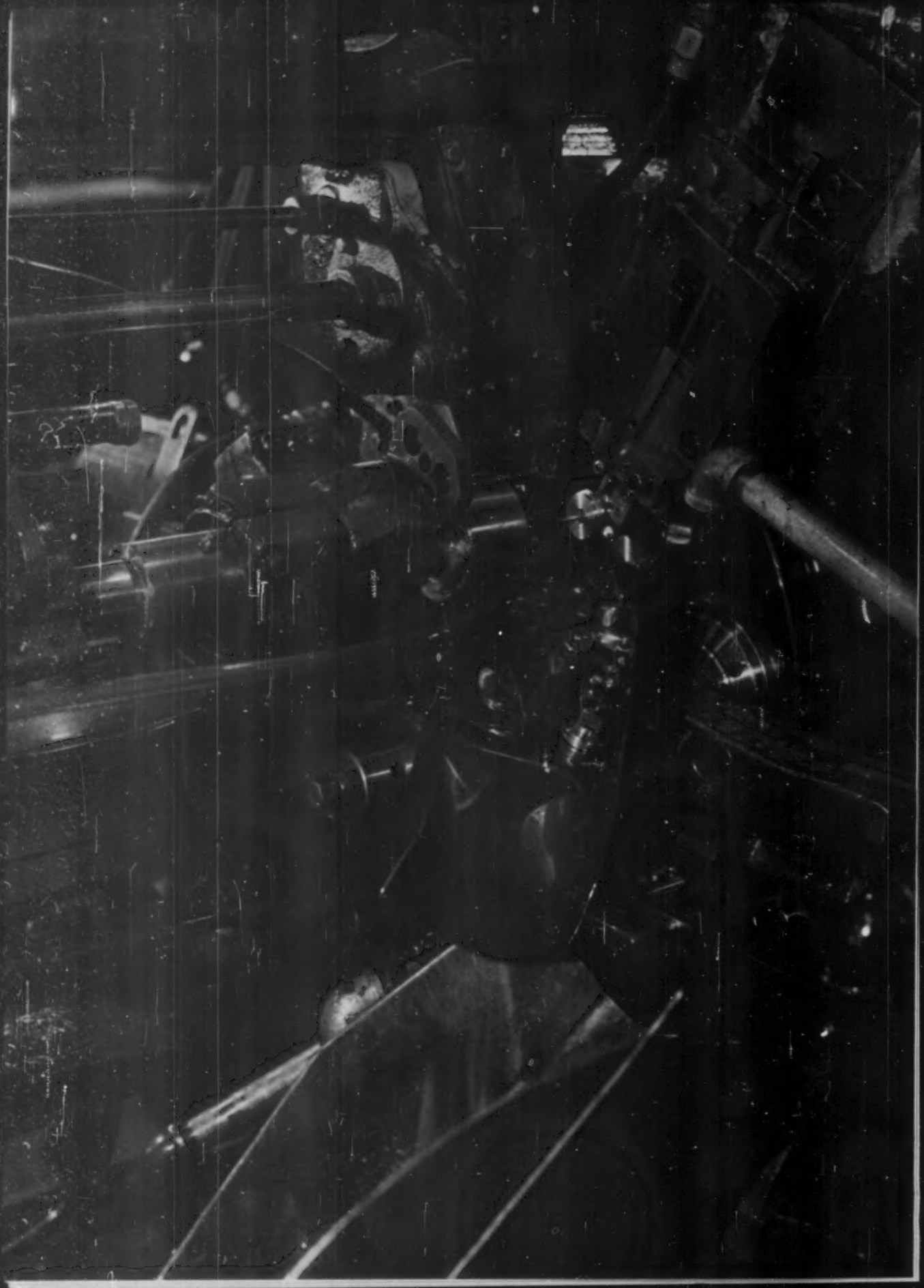
Circle 220 on Page 19

Circle 221 on Page 19→



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Youngstown leaded steels increase your production, prolong tool life

Adding lead to steel is a Youngstown art, hard to learn. You add the right amount at the right time. Disperse it. Keep the content range correct. Check it, test it, inspect it, control it from the teeming floor to finished hot rolled and cold drawn bars.

Youngstown Yolead and other leaded steels give you better machinability, longer tool life and faster cutting speed. You get more reliable performance, improved ductility. You get lower costs. From small carburetor fittings to big automotive forgings, Youngstown can provide the exact leaded grade that you need, when and where you need it.

Get all these advantages with leaded carbon and alloy steels from Youngstown. Get fast, dependable delivery from your Steel Service Center, and through 28 Youngstown offices. Get quality, get performance, get leaded steel from Youngstown who knows how to make lead behave inside steel.

Youngstown – growing force in steel

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All Chicago-Allis packings are available with *anti-friction* impregnations or coatings.

Whether it is a problem of higher pressures, higher temperatures, extreme operating conditions, or unusual compounds or liquids . . . or just a matter of plain efficiency, economy, and dependability . . . there is a Chicago-Allis packing especially suited for the application. C-A products are used across industry . . . automotive, aircraft, home appliances, agricultural equipment, machine tools, and ordnance equipment. Just ask for the assistance of C-A engineers who are always available for counsel on your packing requirements.

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Circle 222 on Page 19

(*Continued from Page 37*)

D. C. Additional information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

Nov. 26-Dec. 1—

American Society of Mechanical Engineers. Winter Annual Meeting to be held at the Statler Hilton Hotel, New York. Additional information can be obtained from Meetings Dept., ASME, 345 E. 47th St., New York 17, N. Y.

Nov. 27-29—

American Management Association. Special Materials Conference to be held at the Savoy-Hilton Hotel, New York. Further information is available from AMA, 1515 Broadway, New York 36, N. Y.

Nov. 27-Dec. 1 —

28th Exposition of the Chemical Industries to be held at the Coliseum, New York. Additional information can be obtained from the exposition manager, E. K. Stevens, International Expositions Co., 480 Lexington Ave., New York 17, N. Y.

Nov. 30-Dec. 1—

Institute of Radio Engineers. Vehicular Communications Conference to be held at the Hotel Leamington, Minneapolis. Additional information is available from IRE, 1 E. 79th St., New York 21, N. Y.

"You find you have to take work home very often?"

Dec. 3-7—

Eastern Joint Computer Conference, to be held in Washington, D. C., under the sponsorship of the American Federation of Information Processing Sciences (Institute of Radio Engineers, American Institute of Electrical Engineers, and Association for Computing Machinery). Additional information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

Dec. 7-8—

Society of the Plastics Industry Inc. Ninth Plastic Film, Sheeting, and Coated Fabrics Conference to be held at the Pierre Hotel, New York. Further information is available from SPI headquarters, 250 Park Ave., New York 17, N. Y.

Dec. 12-14—

American Society of Agricultural Engineers. Agricultural Engineering Exposition and ASAE Winter Meeting to be held at the Palmer House Hotel, Chicago. Further information is available from Shea Expositions Corp., 1 Gateway Center, Pittsburgh 22, Pa.

Short Courses and Symposia

Nov. 6-17—

Short Course on Bearing Technology to be held at the University of California. Additional information is available from Sam Houston, Engineering Extension, Room 6266 Engineering Bldg. 11, University of California, Los Angeles 24, Calif.

Nov. 13-16—

Research Symposium on Electrical Contacts to be held at Pennsylvania State University. Additional information is available from Conference Center, Pennsylvania State University, University Park, Pa.

Nov. 14-15—

Industrial Engineering Seminar to be held at the University of Wisconsin. Further information is available from Engineering Institutes, 3030 Stadium, University of Wisconsin, Madison 6, Wis.

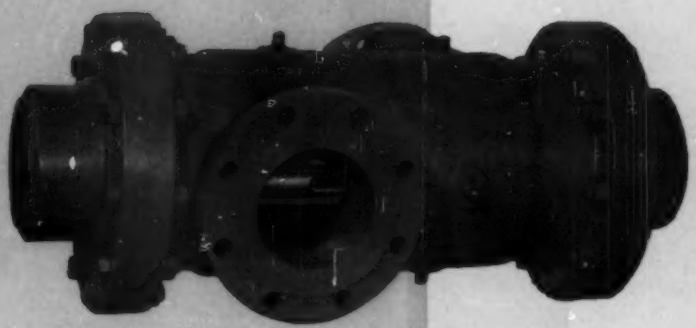
Nov. 14-15—

National Society of Aerospace Material and Process Engineers Symposium to be held at the Bilt-

BIG CONTROL VALVES

up to 8 in. • 5000 psi

2 in., 3-way 3-position, double solenoid type.



8 in., 2-way 2-position, double pilot cylinder type.

Need more flow capacity than you can get with the largest sizes available in most valve lines? There's an easier answer than resorting to costly multiple valving, or redesigning your system to suit flow limitations.

Hunt builds valves in sizes up to 8 in., with air flow ratings of *more than 32,000 cfm* @ 100 psi pressure drop! In fact, you can choose from valves ranging in size from ⅛ through 8 in.; 2 and 3-way, 4-way 2 or 3-position; solenoid, remote-pilot or mechanically actuated; with a variety of optional mountings and features.

If control of large volumes of air, oil, water, or soluble oil and water at pressures up to 5000 psi hyd. is one of your requirements, it'll pay you to talk to your Hunt representative. His specialized knowledge can save you hours and dollars. Call him today.

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VALVES

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iTi IS A BALL
IS EXPERIENCE
IS SKILL

An ancient ivory chess queen—at its base seven balls diminishing in size, each painstakingly carved through holes in the others.

A precision ball, one of millions produced by Industrial Tectonics, Inc.—their sphericity precise to .000005 of an inch, their uniformity to .000010 of an inch and their surfaces smooth to 1 microinch.

Carving the seven ivory balls took long experience and special skill. Manufacturing ultra-precision balls—of over a hundred different materials and precise to millionths of an inch—demands a different application of the same timeless qualities.

SEND NOW FOR "THE PRECISION BALL FOR THE ENGINEER" This newly revised bulletin shows uses and specifications for all types of balls including those of ceramic, high speed steel, sapphire and various alloys. Descriptives on modified balls, tooling balls, master balls and ballizing are also included.

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The Precision Ball is Precisely Our Sphere
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more Hotel, Dayton, Ohio. Subjects to be covered are ceramics and composites, coatings, and solid bodies. Further information is available from SAMPE headquarters, P. O. Box 613, Azusa, Calif.

Nov. 28-29—

Seminar on Direct Energy Conversion Systems to be held at the University of Wisconsin. Additional information is available from Engineering Institutes, 3030 Stadium, University of Wisconsin, Madison 6, Wis.

Dec. 6-7—

Seminar on Electric Machining and Forming (Electro Metal Removal) to be held at the Statler Hilton Hotel, Hartford, Conn., under the sponsorship of American Society of Tool and Manufacturing Engineers. Further information is available from Gilbert E. Seeley, Education Director, ASTME, 10700 Puritan Ave., Detroit 38, Mich.

Dec. 7-8—

Mechanical Engineering Refresher Course to be given at the University of Wisconsin. Further information can be obtained from Engineering Institutes, 3030 Stadium, University of Wisconsin, Madison 6, Wis.

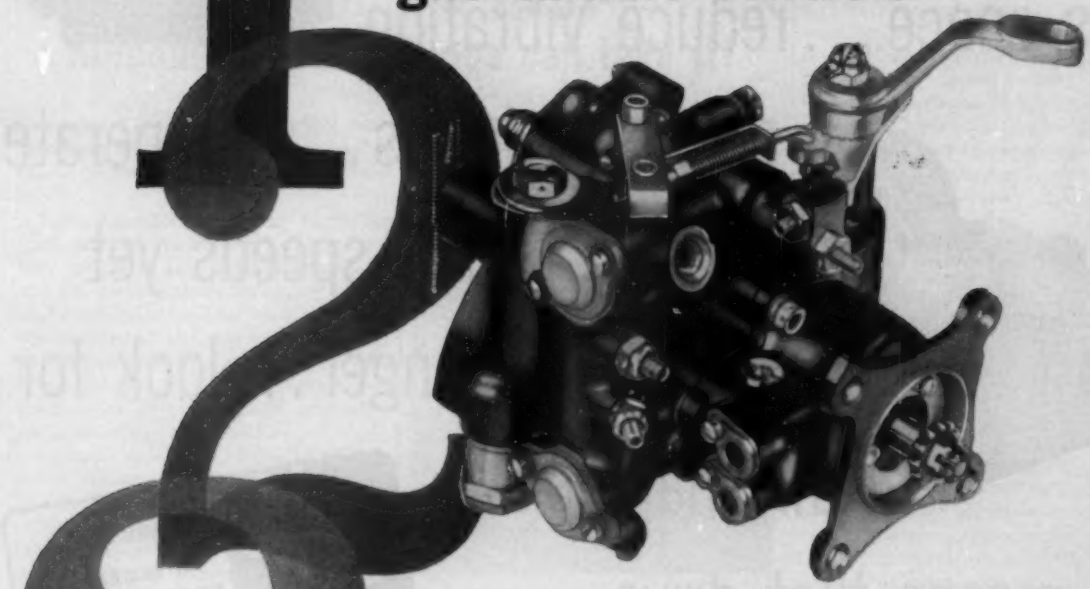
Dec. 12-13—

Seminar on Nondestructive Testing to be held at the University of Wisconsin. Additional information is available from Engineering Institutes, 3030 Stadium, University of Wisconsin, Madison 6, Wis.

Jan. 9-11—

Eighth National Symposium on Reliability and Quality Control to be held at the Statler Hilton Hotel, Washington, D. C. Technical sessions will cover reliability and design techniques, reliability prediction and measurement, mathematics and reliability models, statistical techniques, reliability testing, maintainability, quality control and reliability, reliability programs and management, reliability and quality control education, and reliability training sessions. Additional information can be obtained from Mr. A. R. Park, Mail Stop No. 729, Westinghouse Electric Corp., P. O. Box No. 1897, Baltimore 3, Md.

4 factors to consider in evaluating gas turbine controls



1. Consider design know-how. Bendix employs the systems approach. And we have the demonstrated ability to design and tailor systems that will meet individual needs of all small gas turbines.

2. Consider practical experience. Bendix pioneered in developing fuel metering systems. Already produced: over 1¼ million aircraft carburetors, 34,000 fuel injection systems, and 97,000 gas turbine control systems and components.

3. Consider support facilities. Bendix maintains complete facilities for foundry and heat treat, engine test, qualification test, and development and environmental test, to name a few.

4. Consider production capabilities. Over 3,000 modern machine tools and 500 experienced engineers and technicians. 2,200,000 square feet of manufacturing area.

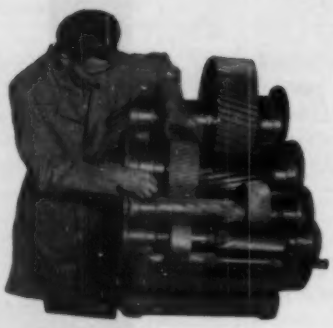
Consider the source, and you'll specify Bendix.
Write Sales Manager, Engine Equipment

Bendix Products Division

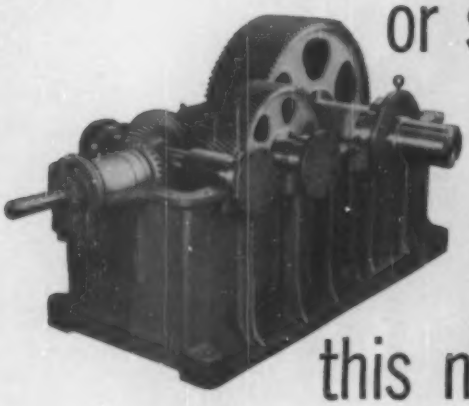
Circle 225 on Page 19

THE Bendix CORPORATION

If you need gear drives that can deliver more power in less space... reduce vibration



or sound levels... or operate at higher speeds yet last longer... look for this nameplate.



It means that drive gearing has been hardened and precision ground to give radically improved gear accuracies. Yet they cost no more. For full details...

write on your company letterhead for "An Advanced Concept in Modern Gearing"

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King of Prussia (Suburban Philadelphia), Pa.

SILICOLOGY *Studies in Silicones*

HOW THESE TIME-TESTED MATERIALS CAN WORK FOR YOU

Turn on the heat—
Silicone-based coatings can take it!

If you were to list the outstanding characteristics of silicone resins, chances are that "heat resistance" would rate near the top.

Paint manufacturers who formulate high-temperature coatings have long been aware of this important property and are turning more and more to silicone resins as a base for their products. These range all the way from high-temperature enamels for electrical appliances to special paints used on rockets and missiles, jet aircraft engines, and other advanced space vehicles.

In many cases, the choice in silicone resins inevitably leads to one made by UNION CARBIDE, not only because of their unmatched reliability and uniformity, but because each has been scientifically designed to meet a specific paint requirement.

LOW-TEMPERATURE CURE

Take UNION CARBIDE R-630, for instance, a new low-temperature curing resin which has been widely adopted by the paint industry as a base for appliance finishes and for paints on engines, motors, generators and other high-temperature electrical equipment. Enamels based on R-630 are free from many of the handling problems inherent in the use of other silicone varnishes and may be applied over any metallic surface by spraying, flow coating, brushing, or dipping. Lighter in weight, more flexible and less expensive than ceramic coatings, it can be blended with acrylic enamels to give them improved thermal stability and resistance to weathering.

The color range is virtually limitless, and high-temperature enamels based on R-630 have outstanding durability, salt spray resistance and water-repellency. In addition, paints based on R-630 can be packaged in aerosol sprays for consumer use on home ovens, stoves and radiators.

LOW-COST ALUMINUM PAINTS

To combine economy with performance, many large-scale users of paints are adopting UNION CARBIDE R-64, a silicone resin which can be cold-blended easily with many organic resins as vehicles for aluminum paints. With only 7 to 11 per cent by weight of resin needed in the formulation, aluminum paints of this type give outstanding protection in the 500-1200 deg. F. range and still retain their silvery appearance under these high-temperature conditions.

Silicone base aluminum paint, which provides surface protection up to 1700 deg. F., is sprayed on rocket engine jig at Rocketdyne plant of North American Aviation. The paint, known as CI "Extra High," is made by Chem Industrial Co., Cleveland, O., and is based on silicone resins made by Union Carbide.

Applied by brush or spray, such paints are used as protective coatings for aircraft engines and exhaust stacks, truck and engine manifolds and mufflers, furnaces, ovens, stove and heater doors, and metal smoke stacks. Heat and flame-resistant protective clothing can also be fabricated from asbestos cloth coated with aluminum paints based on R-64 organic blends.

MAXIMUM THERMAL STABILITY

If factors of heat, weather and corrosion constitute a major problem for you, take a look at still another UNION CARBIDE product, R-611. Developed specifically as a resin vehicle for metallic and non-metallic pigmented high-temperature enamels, it provides the *ultimate* in thermal stability and offers far greater heat, weather and corrosion resistance than organic paints. Typical applications are in paints for ovens, incinerators, high-temperature electrical appliances, lamp shields and reflectors, smoke stacks, piping, engines, motors, generators and high-temperature processing equipment such as are found in many chemical and metallurgical industries.

R-611 based paints can also be packaged in aerosol sprays for consumer use on home ovens, stoves and radiators.

LASTING QUALITY

Silicone-based coatings mean savings because they provide protection for longer periods of time. If you have a coating performance problem, look to UNION CARBIDE Silicones for your answer. Your Silicones Man is at your service. Behind him is not only his know-how, but the vast experience and research of Union Carbide Corporation in virtually every field of industry. For information and help, fill in the attached coupon and mail it today.

UNION CARBIDE

SILICONES

UNION CARBIDE is a registered trade mark of Union Carbide Corporation.

Silicones Division
Union Carbide Corporation
Dept. JL-6101, 30-20 Thomson Avenue,
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In Canada: **Union Carbide Canada Ltd., Bakelite Division, Toronto 12.**

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COMPANY _____

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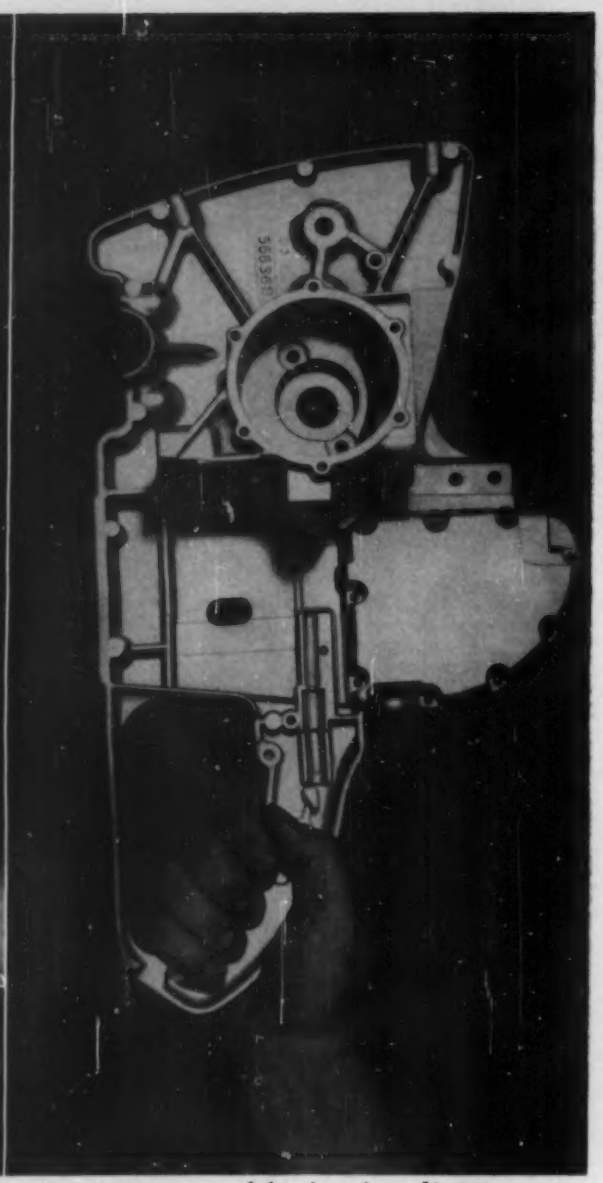
CITY _____ ZONE ____ STATE _____

Circle 227 on Page 19

Multi-part assembly...



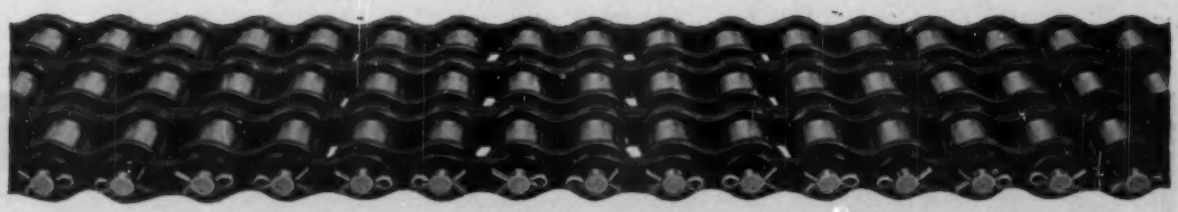
or "assembly in the die?"

WHICH PROVIDES THE COST-CUTTING EDGE FOR YOUR PRODUCT?

If your product involves the assembly of two or more related metal parts, the chances are you can make important savings and a better product by having assembly "done in the die." Skilled one-piece die casting by Doehler-Jarvis cuts tooling and metal costs to the bone . . . saves you time and money at every assembling and joining stage. You save on rejects, too — in one-piece die casting, there are no such things as mismated parts. We call it UNITATION . . . the unique Doehler-Jarvis combination of unitizing and automation that produces the part you want in a single, strong casting. To learn how you can benefit from UNITATION, why not let an experienced D-J engineer take a hard analytical look at your cast, formed or assembled metal parts. His suggestions may save you thousands of dollars. Write or call.

DOEHLER-JARVIS
DIVISION OF NATIONAL LEAD COMPANY

GENERAL OFFICES: TOLEDO 1, OHIO. PLANTS AND SALES OFFICES: TOLEDO, OHIO; GRAND RAPIDS, MICHIGAN; POTTSTOWN, PENNSYLVANIA; BATAVIA, NEW YORK. IN CANADA: BARBER DIE CASTING CO., LTD., HAMILTON, ONTARIO. IN BRAZIL: INDUSTRIAS DOEHLER DO BRASIL, S. A., SAO BERNARDO DO CAMPO, SAO PAULO. IN ARGENTINA: DOEHLER ARGENTINA, S. A., BUENOS AIRES. IN GREAT BRITAIN: METAL CASTINGS-DOEHLER, LTD., WORCESTER, ENGLAND.



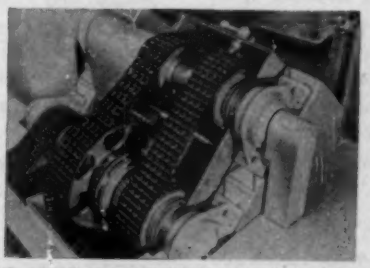
Here's
another of the
invisible extras that
insure the precision performance
of LINK-BELT roller chain

prestressing of multiple-strand chain guarantees

uniform load distribution

Unless each strand carries its full share of the load, multiple-strand roller chain may fail. That's why Link-Belt's prestressing is so vital. Prestressing seats and cold-works the chain joint parts . . . assures equal load distribution across the chain, reduced elongation in service.

Prestressing is just one of many *invisible extras* that contribute to the greater strength and endurance of Link-Belt roller chain. Others include precise heat-treat control, pitch-hole preparation, shot-peening and burnishing of rollers. These features—plus painstaking precision and inspection in every step of manufacture—assure you of chain that can easily cope with today's heavy loads and high speeds.



Quadruple-strand Link-Belt roller chain drives are used on this two-speed transmission. High speeds on short centers are easily handled.

For engineering assistance in applying industry's preferred roller chain, contact your nearest Link-Belt office. Look under chains in the yellow pages of your local telephone directory. Ask for Book 2657.

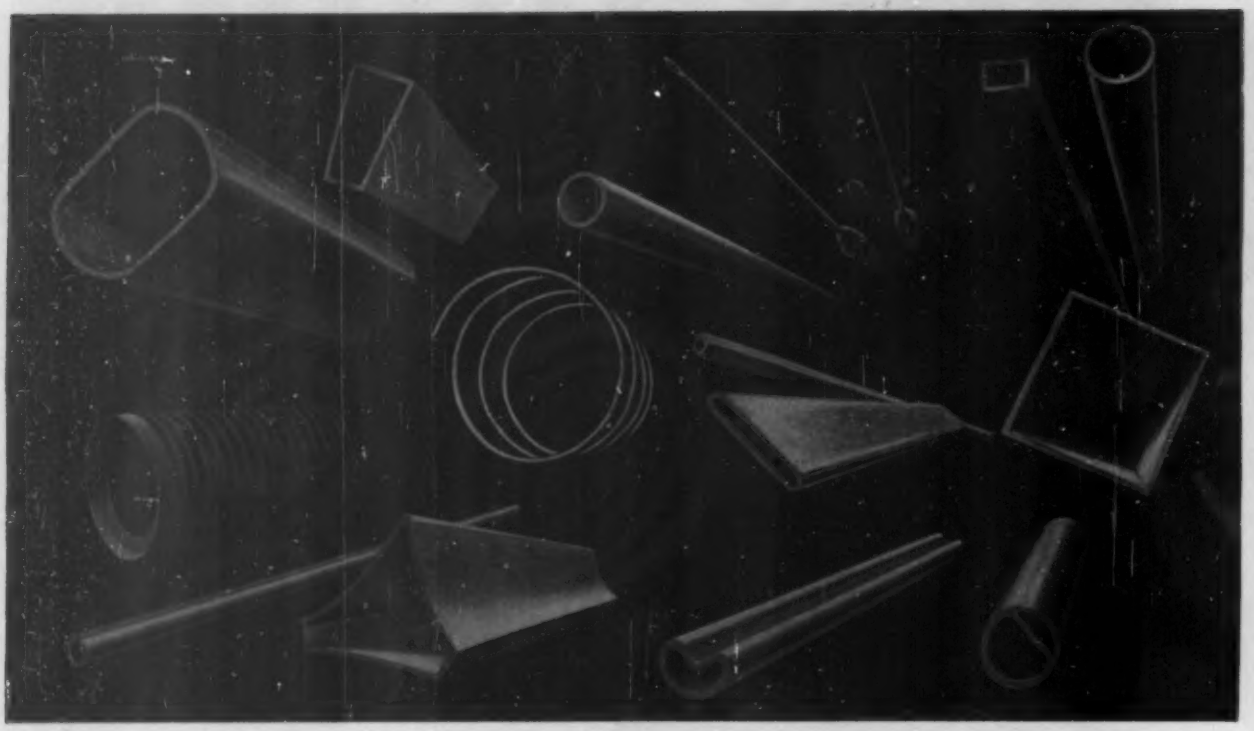
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 11,017

LINK-BELT

ROLLER CHAINS AND SPROCKETS

Circle 229 on Page 19

Tomorrow's tubing technology—today



RSVP SUPERIOR

Reliability, Selectivity, Volume, Precision—in close-tolerance, small-diameter tubing

In all these categories, Superior meets your most exacting requirements. **Reliability.** We build in tubing reliability by an established quality-control system, which uses such precision equipment as air gages, optical comparators, torsion balances and ultrasonic gaging devices—all calibrated true to standards. We verify tubing reliability by nondestructive tests, when required, with any of the following methods singly or in combination: eddy current, dye penetrant, fluorescent dye penetrant, ultrasonic, radiographic, hydrostatic, boroscopic and magnetic particle.

Selectivity. Only Superior offers a choice from more than 120 analyses, including carbon and alloy steels, stainless steels, nickel and nickel alloys, glass sealing alloys, Super Alloys, reactive metals and composites. Sizes in all analyses range from .010 through ⅝ in. OD. Certain analyses in light walls up to 2½ in. OD.

Volume. Superior is a volume producer of quality tubing. Mill flexibility permits us to produce all orders with equal care—whether they are for 50 or 1,000,000 ft.—and ship on the day promised. And Superior's modern mill is staffed with skilled metallurgists and technicians working with seasoned production men who solve the most difficult tubing problems and make the finest small-diameter tubing in the world.

Precision. Making precision products such as Bourdon, capillary and needle tubing is routine. Exceptionally close tolerance requirements are met frequently. For example, on an order for C-1008 steel tubing with an OD of .501 in. and an ID of .442 in., we held the OD tolerance to +.0005 −.000 in., 10% of commercial tolerance for this OD. The ID was held to +.002 −.000 in., or less than one-half commercial tolerance.

And to give you on-the-job assistance, we maintain a staff of field specialists recognized as experts by an organization of Steel Service Centers and their customers.

LOOK FOR THESE PRODUCT INSERTS !

They give pertinent information about a few of the many Superior products, including both standard and special items used extensively by industry. If you would like more data about Superior Tube Company and its products, fill in the coupon.

RETURN THIS COUPON FOR COMPLETE DATA

Superior Tube ST

The big name in small tubing

NORRISTOWN, PA.

West Coast: Pacific Tube Company, Los Angeles, California

SUPERIOR TUBE COMPANY
Norristown, Pa.

Please send me your "Selection and Application Guide" for small-diameter tubing.

Name_____ Title_____

Company_____

Street_____

City, Zone, State_____

Circle 230 on Page 19

SEALMASTER®

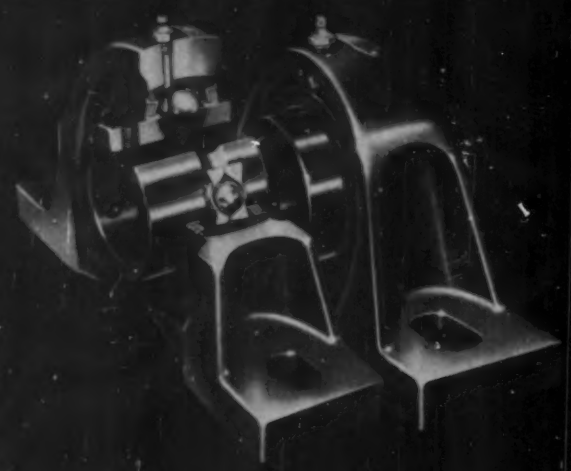
Two products... one standard of quality!

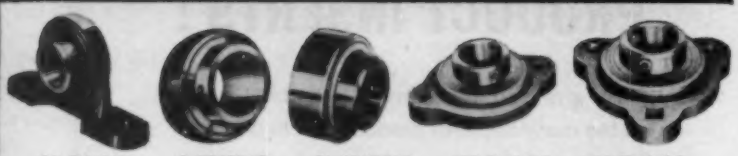
SPHERCO®

SPHERICAL BEARINGS & ROD ENDS

SEALMASTER®

BALL BEARING UNITS





LP PILLOW BLOCK | L BEARING | SL BEARING | LFT FLANGE UNIT | LF FLANGE UNIT

Normal-Standard Medium Duty PILLOW BLOCKS | Standard Medium Duty FLANGE UNITS | FLANGE CARTRIDGE UNIT | TAKE-UP UNIT | TWO BOLT FLANGE UNIT

SEALMASTER

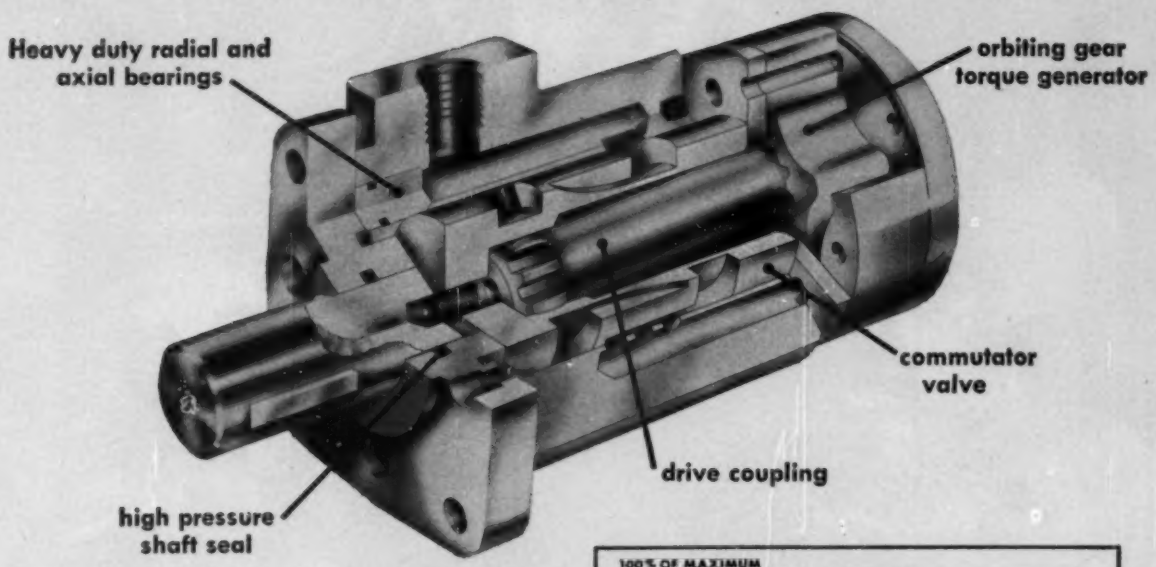
SEALMASTER BEARINGS

Sealmaster bearings offer a complete line of mounted units to meet every requirement. This line offers the ultimate in quality and performance at the most economical level.

WRITE TODAY FOR SEALMASTER CATALOG 454

Circle 231 on Page 19

New Hydraulic Motor Design Provides High Torque at Low Speeds



ORBIT MOTORS®...

DELIVER MORE TORQUE PER LB and AT LESS COST

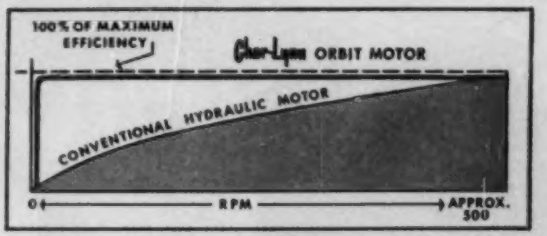
The Orbit principal utilizes an internal gear mechanism to act both as a fluid displacement motor and a gear reducer. The outer segment is a stationary part of the motor housing and has internal gear teeth which mesh with corresponding teeth on a smaller gear or rotor which rolls inside the outer gear, turning about an eccentric axis in an ORBIT.

The rotor gear rolls through six complete orbits during each single rotation of the output shaft. Thus an effective speed reduction of 6-to-1 is obtained. The use of seven fluid chambers with the inherent 6-to-1 ratio provides 42 fluid power cycles per shaft rotation, a distinct advantage in obtaining smooth rotation.

As it rotates, the rotor gear causes a continuous opening and closing of the spaces between the teeth. Half of these spaces are subjected to fluid pressure and the opposed half is connected to the return section of the motor.

The rotary commutator valve distributes the fluid so that the pressured space rotates in phase with the rotor gear, thus causing continuous rotation. Motion of the rotor gear is transmitted to the output shaft by a coupling which has crowned involute splines to match the bores of the output shaft and the rotor gear.

The high pressure shaft allows ORBIT MOTORS to be operated "in series" without external drain lines.



High efficiency over complete operational range

- **Speeds from 0 to 800 rpm**
- **Torques to 3300 inch lbs.**
- **Starting torque substantially equal to running torque**
- **Full reversible—instant starting, stopping**
- **Only 3 moving parts**
- **4 types of mountings available**
- **3 port sizes, 7 power element selections**
- **Compact, light weight**
- **Eliminates costly and complicated power transmissions**
- **High volumetric and overall efficiency**

For Complete Details Write—

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Char-Lynn
HYDRAULIC HORSEPOWER PRODUCTS

We offer recommendations designed for the application

ALLISPEDE® DRIVE
A low cost, accurate mechanical drive. Easily adjusts manually or by optional electric remote control. Simple maintenance. Speeds up to 10,000 RPM, speed ranges from 10:1, ½ to 30 HP. Configuration can be readily changed in the field to meet new requirements. Ask for Bulletin 3601.

SELECT-A-SPEDE® DRIVE
Converts incoming AC power to DC output at the motor to provide a highly responsive, precision drive. Drive motors are available in all types of enclosures. Transistorized control panels permit easy field modifications at any time to suit changing conditions. Available in ratings up to 400 HP. Ask for Bulletins 101 and 2001.

MAGNETIC DRIVE
For applications from 50 to 2500 hp. Liquid cooled magnetic clutch provides precision controlled adjustable speed. Wide speed range with minimum of drift. Available in one, two, three, or four-field construction . . . with or without magnetic brake. Ask for Bulletin 3650.

SYNCRO-RANGE DRIVE
A sophisticated "package system," Syncro-Range Drive from 2 to 200 hp combines an adjustable frequency power supply with compact squirrel cage induction or Syncro-Spede® synchronous motors. Controller offers one-point control of multi-motor process lines. Ask for Bulletins 110, 111, 112.

AJUSTO-SPEDE® DRIVE
Eddy current clutch and a-c motor combination provides stepless, accurate speed control. No brushes, slip rings, or commutators. Simple one-dial control. Sizes ¾ to 100 HP. Offered with wide variety of features including transistor control. Ask for Bulletins 2750 and 2800.

®TM of Eaton Mfg. Co.

NEW design news from Louis Allis

Louis Allis "systems engineering" can provide control for a single process line . . .

or entire plant coordination!

An outstanding line of LOUIS ALLIS adjustable-speed drives from ½ to 2500 hp.

Louis Allis offers you a complete line of adjustable-speed drives with various characteristics for every application where adjustable speed is required.

Experienced Louis Allis field engineers will help you select the best drive for your application. They are supported by regional and factory industry specialists who can recommend a drive system to meet *your* requirements.

The Louis Allis line of drives provides outstanding control features ranging from simple manual to precise electronic or transistorized control. Selection of control varies, of course, with the nature of the installation and the precision required. Where desirable, speed regulation as close as .1% is obtainable.

Controls can be provided which automatically respond to temperature, pressure, or flow. Other control features include threading, inching, jogging, logarithmic acceleration, torque-limit acceleration, tachometer feedback . . . and many other control provisions that can exactly tailor a Louis Allis drive to *your* operation.

For process plants or applications involving inter-related motors and multiple drives, Louis Allis engineers can provide complete "systems engineering" furnishing all electrical rotating components and control.

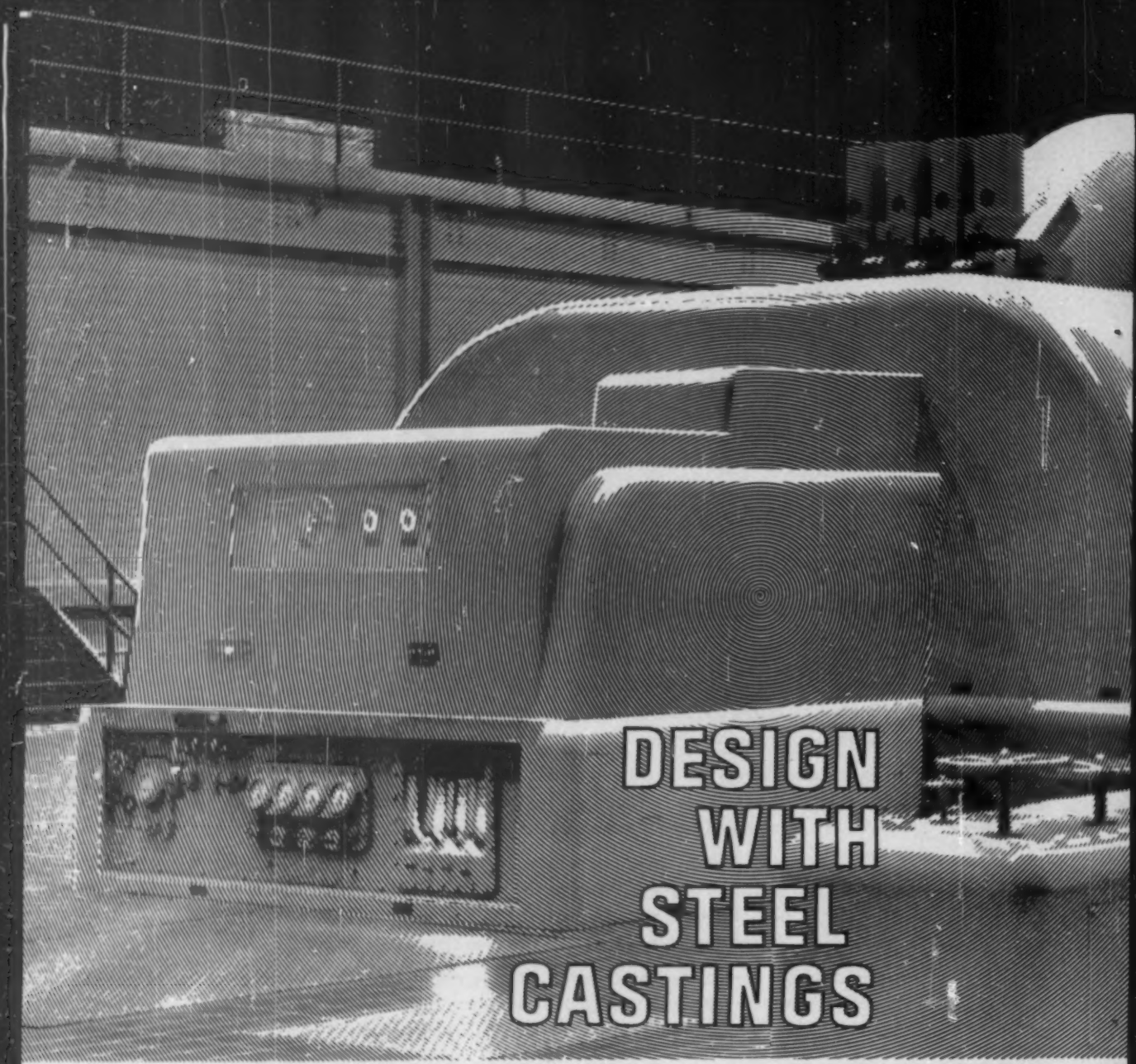
For expert assistance call your local Louis Allis District Office listed in the Yellow Pages under "Electric Motors" . . . or write direct to The Louis Allis Company, 459 E. Stewart St., Milwaukee 1, Wisconsin. Ask for Bulletin 2900.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

A20-220

Circle 233 on Page 19



for low end cost

Take a *dollars-and-sense* approach to component costs at the planning stage. You'll soon discover how quickly steel casting expense ends and benefits begin.

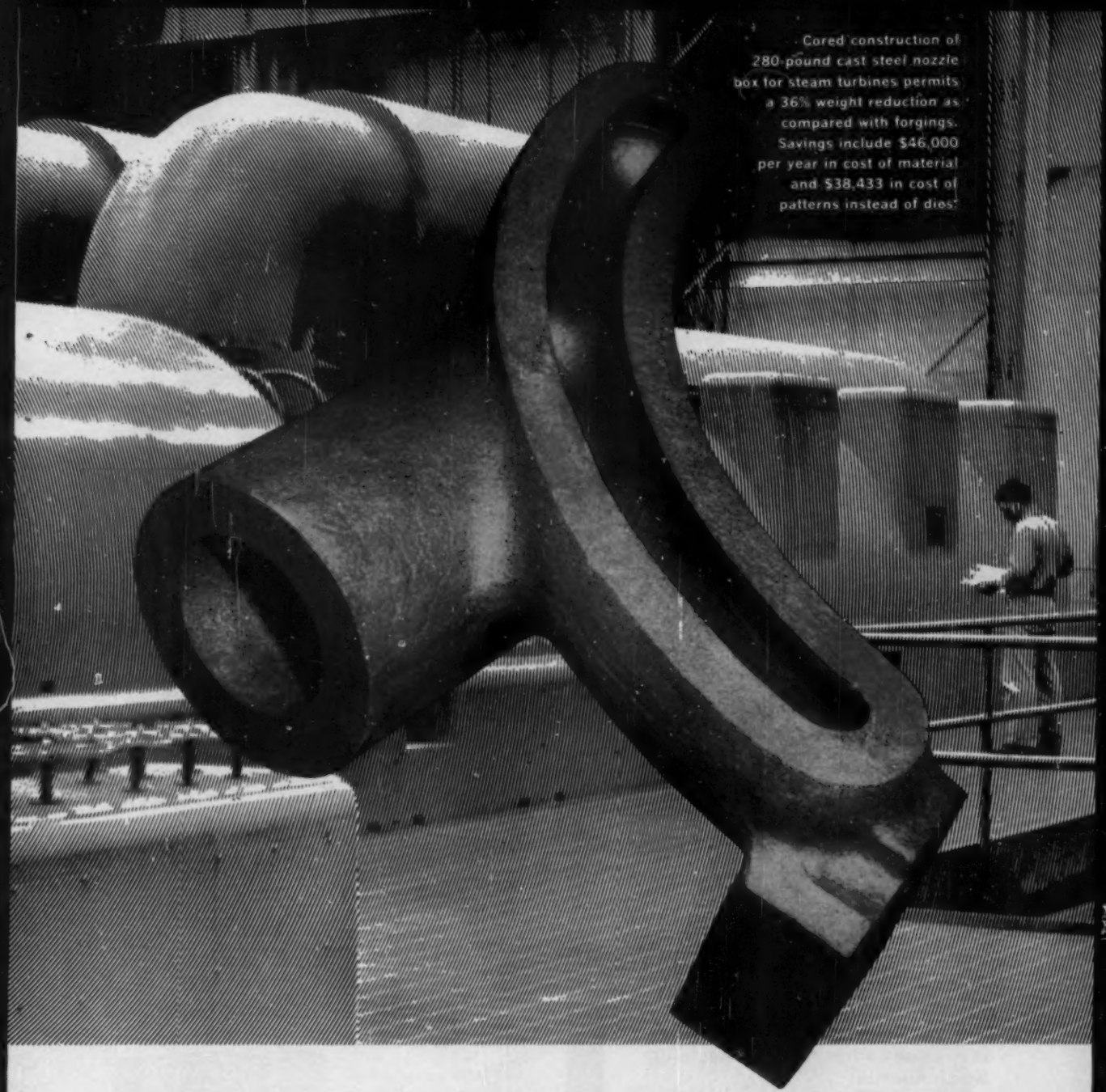
Steel castings don't require costly dies, or special tools, shears or presses. They're made with patterns. And they can be cast to final contour. You minimize milling and boring, die sinking and planing, contouring and profiling.

Then too a steel casting is an *integral* unit. Not a collection of pieces that must somehow be put together. You eliminate assembly costs—and costly assembly errors.

And steel castings slash material and shipping costs by giving strength without dead weight.

Steel castings meet the designer's desire for flexibility, the production man's concern with manufacturing economy, the customer's demand for low-cost dependability.

Talk with your steel foundryman. Learn how your vital components can be cast for optimum economy, strength and shape.



Cored construction of 280-pound cast steel nozzle box for steam turbines permits a 36% weight reduction as compared with forgings. Savings include $46,000 per year in cost of material and $38,433 in cost of patterns instead of dies.

low end cost plus

FUNCTIONAL DESIGN . . . metal where you need it.

WIDE SELECTION OF PROPERTIES . . . for a variety of demanding applications.

BENEFICIAL GRAIN STRUCTURE . . . assures optimum multi-directional strength.

DIMENSIONAL UNIFORMITY . . . consistent duplication of the part.

SHOCK RESISTANCE . . . for shock and impact resistance in compression, tension, torsion and shear.

SERVICE STABILITY . . . resists deflection and deformation of parts.

CAST-WELD & COMPOSITE FABRICATION . . . permits economical joining of single castings, or fabricating with other materials.

PROCESS FREEDOM . . . can be readily hot or cold pressed, brazed, plated, coated, and many other process operations.

Advantages of steel castings and complete engineering information are detailed in the STEEL CASTINGS HANDBOOK. Send the coupon for information about this 680-page book.

NAME_____

TITLE_____

COMPANY_____

STREET_____

CITY_____ ZONE____ STATE_____

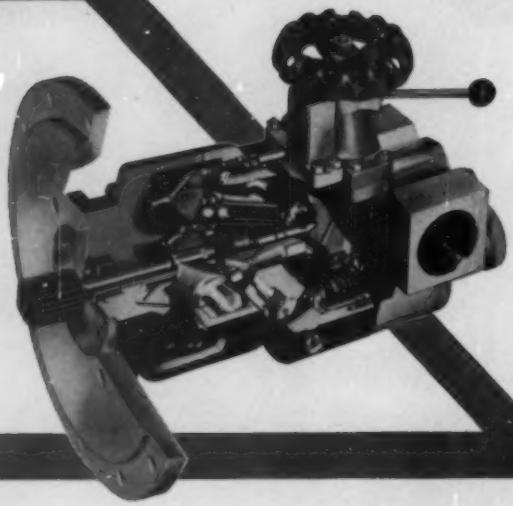
DESIGN WITH STEEL CASTINGS CENTENNIAL 1861 1961 STRENGTH IN SHAPE

STEEL FOUNDERS' SOCIETY OF AMERICA

606 TERMINAL TOWER • CLEVELAND 13, OHIO

Circle 234 on Page 19

Nine piston, variable volume, pressure compensated type IA-38-9 pump, designed for use on Ground Support Equipment.



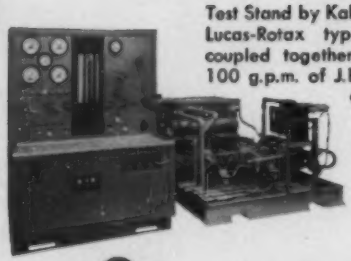
VERSATILITY-PROVEN *lightweight hydraulic* PUMPS AND MOTORS

Well known equipment manufacturers are specifying Lucas-Rotax hydraulic pumps and motors because they offer

- size and weight advantages in the 4 to 104 g.p.m. flow range
- pressures up to 5000 p.s.i.
- low noise level
- other attractive design features

Lucas-Rotax provides full engineering, sales and service throughout North America.

Your hydraulic requirements will be met by contacting Lucas-Rotax Limited, Toronto.



Test Stand by Kahn Company. Three Lucas-Rotax type IP-525 pumps coupled together provide flow of 100 g.p.m. of J.P.4 fuel for testing aircraft equipment.

Marine winches by Timberland-Ellicott are powered by Lucas-Rotax pumps and motors.

Two IA-38 pumps are incorporated in the portable Test Stand by Consolidated Diesel for use in checking out hydraulic system components on fighter aircraft at 5,000 p.s.i.

products of creative engineering by

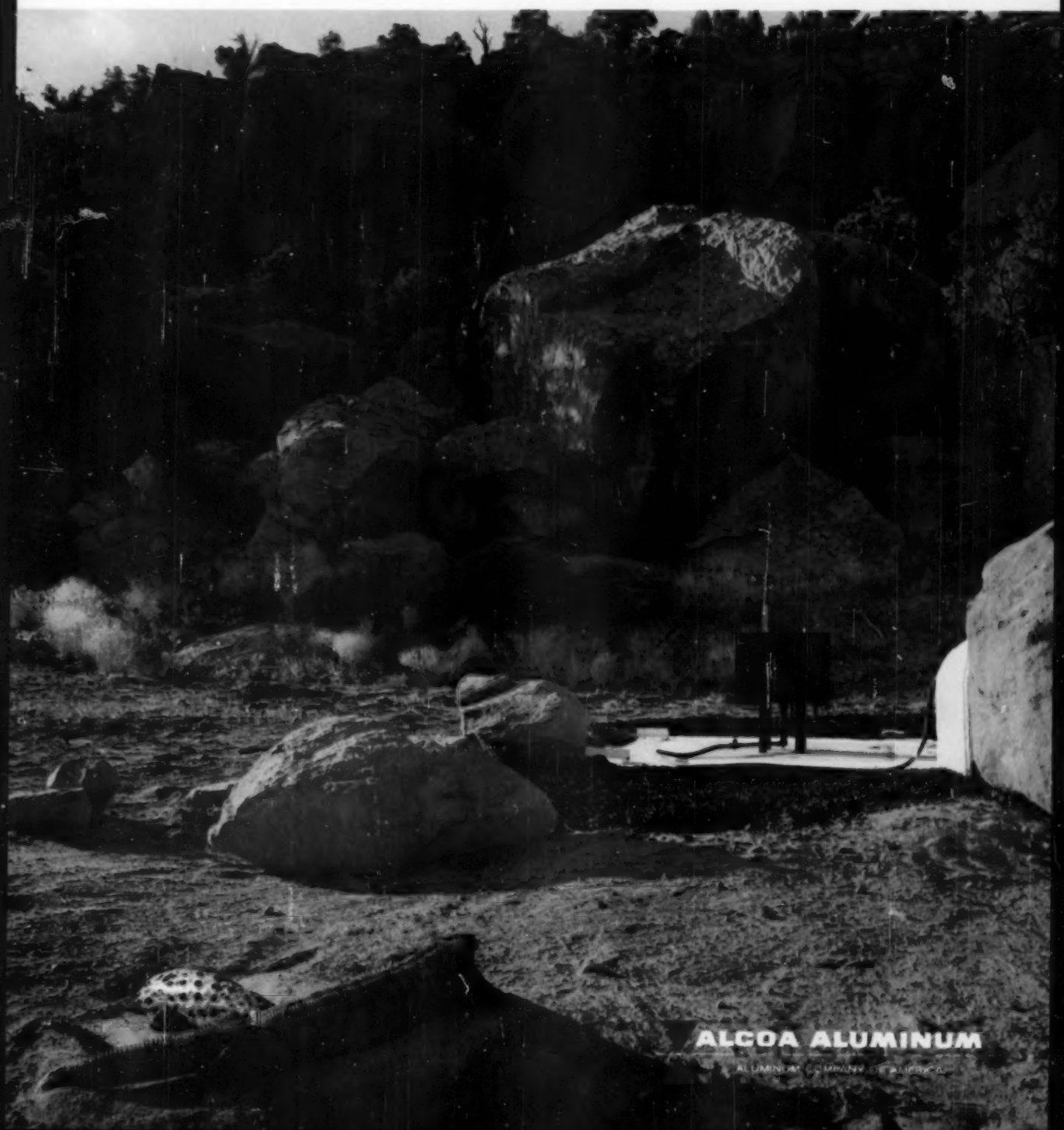
LUCAS-ROTAX

LIMITED
2200 EGLINTON AVE. EAST, TORONTO, ONTARIO.
POSTAL ADDRESS: BOX 115, STATION H, TORONTO 13. 6102

Circle 235 on Page 19

Circle 236 on Page 19→

When a 37-lb generator converts heat directly to electricity . . .



When a 37-lb generator converts heat directly to electricity...

...that's Alcoa Total Ability at work!

The metal structure in the picture at the left is 13 in. square and weighs 37 lb. It has no moving parts. Yet it will generate a steady 50 watts of electricity for years with no maintenance.

It's a Westinghouse thermoelectric generator being tested by El Paso Natural Gas Co. in a remote area of New Mexico. Its power is used for cathodic protection of underground gas well casings.

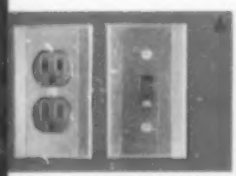
A gas flame burns in the core of the generator at 800°F. To convert the flame's energy into electricity requires a temperature differential of 580°F be maintained between the "hot" and "cold" ends of semiconductors less than an inch long. Only a highly efficient heat sink could do the job in this sweltering desert. Alcoa® Aluminum, with its remarkable heat-dissipating properties, was found to be the most economical answer.

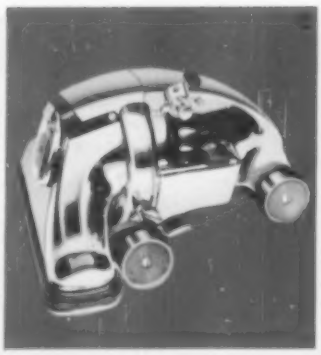
With Alcoa's help in alloy selection, black-anodizing and brazing techniques, Westinghouse engineers fabricated the finned heat sink for this prototype model from sheet. In production models, the heat sink will be extruded and the generator "core," which encases the gas flame, will be formed in an *impact press* from Alcoa powder-metallurgy alloys.

Chances are Alcoa can help you make savings and short cuts in your electrical manufacturing. We operate the world's most extensive light-metals research and development facilities. We are the only basic producer fabricating aluminum by every practical method. We have no axe to grind for any particular process. *Alcoa Total Ability* will help you select the right alloys and the most economical methods. Simply call your nearest Alcoa sales office, or write: Aluminum Company of America, 856-X Alcoa Building, Pittsburgh 19, Pa.

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA





ALCOA TOTAL ABILITY SERVES THE ELECTRICAL MANUFACTURING INDUSTRIES...

A. Tumbler switch and duplex receptacle produced by Leviton Manufacturing Company with Alcoa Aluminum satin finish wallplates.

B. Die-cast aluminum electric iron sole plate.

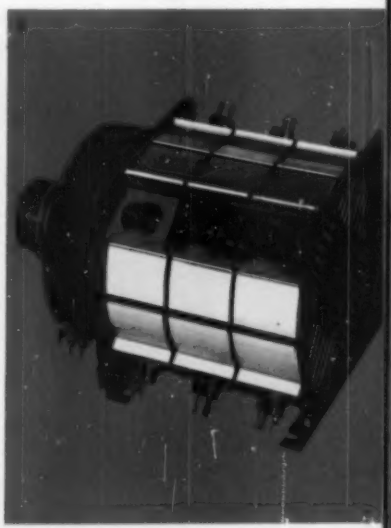
C. Kirby vacuum sweeper made by the Scott & Fetzer Co. Nozzle, headlight cap and shell housing are Alcoa die castings.

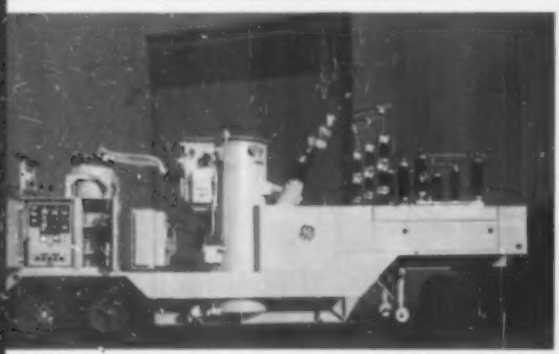
D. Mobile substation built by General Electric Company with aluminum transformer tank, coolers, switch framework and side panels.

E. All-aluminum reactor cages at a Philadelphia Electric Company substation.

F. DELTA-T Modular FCA-800 Semiconductor forced convection cooling package. One of many models with Alcoa Aluminum anodized extrusions by Wakefield Engineering, Inc.

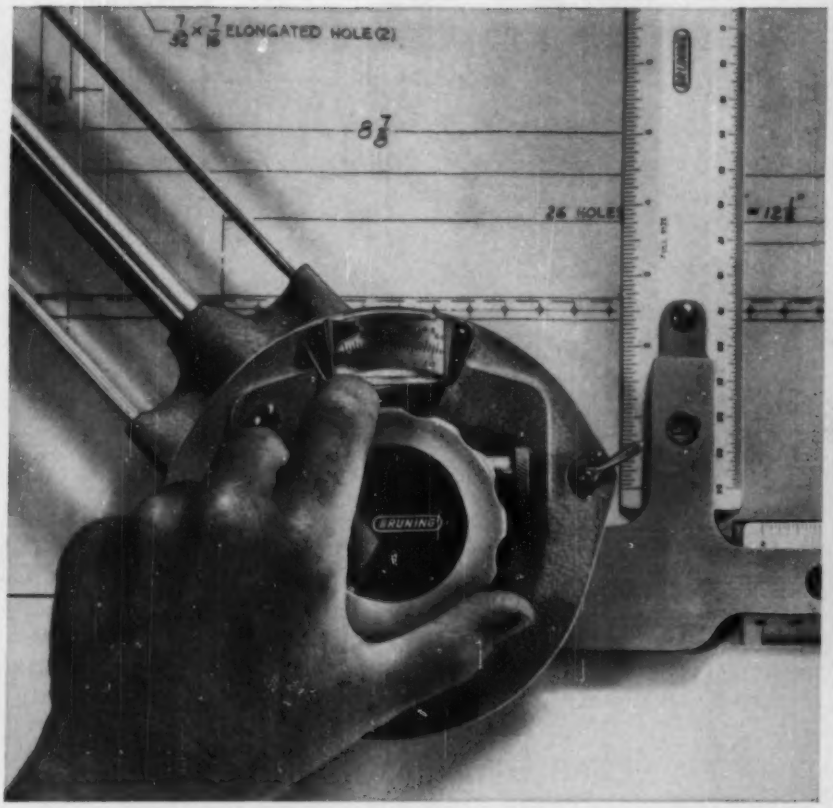
G. A 60-ft radar antenna by D. S. Kennedy & Co. employs Alcoa aluminum tube and expanded sheet, has withstood ice loads over 5 in. and winds over 150 mph.

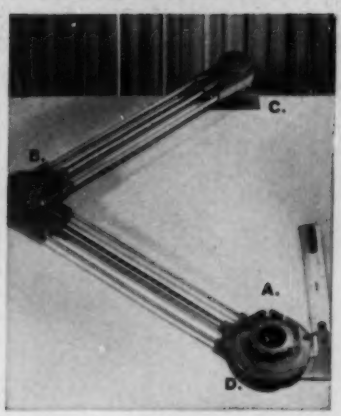




You get more accurate readings... faster with this

NEW BRUNING *Equipoise* DRAFTER





The finest is *further* refined! Long a favorite as a *single instrument* that does the work, through an arc of 360°, of *five* basic tools (T-square, straight edge, triangles, scale, and protractor)... Bruning's new Equipoise drafter now brings even greater benefits to draftsmen.

CLEARLY, YOUR CHOICE IS BRUNING

A. New Magnifier Lens on the now *totally enclosed*, fully protected protractor assures faster, more precise, double vernier readings.

B. New Elbow Adjuster assures smooth, non-slip drafter operation on intermediate board angles *inclined as high as 25°*.

C. New Leveling Screws permit easy and accurate mounting of the machine on boards of moderate warpage or surface irregularity.

D. New Baseline Lock brings speed and ease to baseline setting; makes it easy to adjust *drafter* to *drawing*.

For further information, clip and mail the coupon.

CHARLES BRUNING COMPANY, INC. MD-10
1800 West Central Road, Mt. Prospect, Ill.
In Canada: 103 Church St., Toronto 1

☐ Please send information on the New Equipoise
☐ Have representative call me

Name.....*Title*.....
Company.....
Address.....
City.....*County*.....*State*.....

←Circle 236 on Page 19

Circle 237 on Page 19

Take a close look at this new limit switch! It's so immune to moisture, we'll guarantee it, electrically and mechanically, for one year or 10,000,000 operations . . . whichever comes first. We call it our Super-Sealed SL2-T. If you've ever had limit switch trouble caused by water, soluble oils, condensate or *any* kind of moisture, you'll want complete details. Call, write or wire.

National Acme

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188 E. 131st STREET
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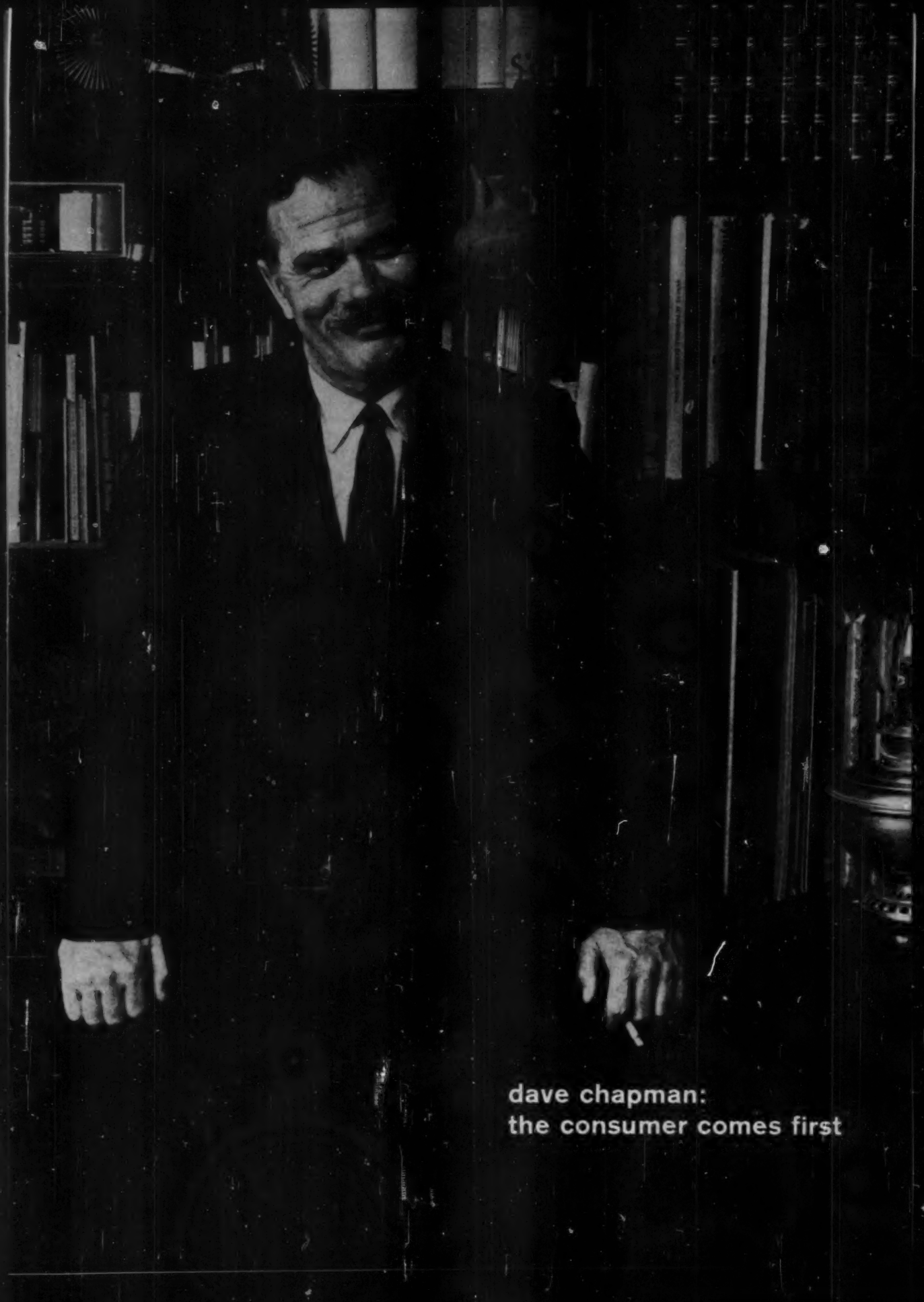
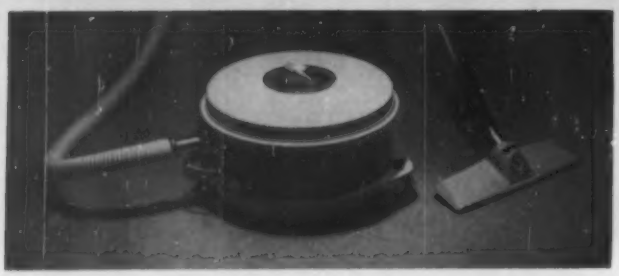


dave chapman:
the consumer comes first



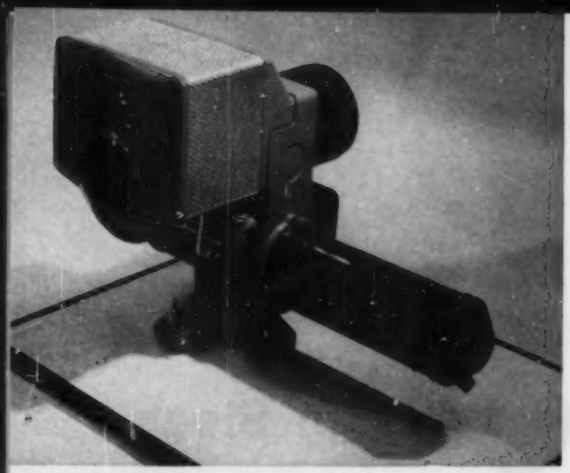
chapman talks design

Dave Chapman has been a successful industrial designer for over 25 years because he has succeeded in designing products for people. Not every manufacturer does. Says Chapman, "Too much of marketing has been a kind of seduction. We have to deal in real values. We have to make things so they'll be rewarding to people. In our basic approach to any design problem, the consumer is always our primary point of reference."

Chapman has maintained this outlook about people since his first venture into design in 1933. He was one year out of Armour Institute and working in Montgomery Ward's architectural department designing branch stores when Sewell Avery, one of the Depression years' most creative merchants, asked him to build a newly formed product design department. Under his direction 18 designers, in one of America's first product design organizations, applied the famous concept "Form follows function" to retail marketing. Says Chapman of Avery, "His was a clear voice out of the confusion of visual and economic chaos, insisting that goods well-manufactured and well-designed, from good materials, would sell."

And sell they did. Dave Chapman left Montgomery Ward in 1936 with new horizons in view. But unlike other early practitioners of change, who gravitated to New York, Chapman opened up shop in Chicago. It was the heart of industrial America. And Chapman today can look back on an unbroken string of design successes, awards and honors including a stint in 1950 as the youngest man ever to hold the presidency of the American Society of Industrial Designers.

What has been the biggest change in industrial design since those early years? The selling process. The sale used to be made by the retailer in his shop. "Now the sale is designed at the conference table of the manufacturer. The sale is made in a designer's office, on television, or in the pages of a mass magazine. The designer, therefore, has changed from a stylist to a liaison between engineering and the consumer." Therein lies the designer's severest problem. Assuming he starts with satisfying people in product design, his job isn't done until he can convince a manufacturer to think of design and markets in long-range terms. "Too many manufacturers



look at design merely as a crash-rush-got-to-have-it-ready-for-the-June-market problem. First, they should make design a major marketing force in their future planning; second, once they have a good design they should refrain from seeking out all the reasons why it *can't* be produced."

Here is the Chapman formula: "The surest route to increased sales: working closely with our clients for design solutions that meet consumer demands for improved function, reduction in cost to the consumer, and/or more pleasing or gratifying appearance. When you achieve these, the consumer will have a real reason to buy, a salesman will have a product of real value to sell, the manufacturer a product of real integrity to produce."

Also in the formula: picking the right material for the job. Chapman decries the lack of research that is being done in industrial design. He wants to know more about what can and cannot be done with materials, so that when he or one of his 35 designers sits down to design an item, their considerations of the mechanical possibilities and limitations are unlimited.

Considering his preference for known possibilities, it is hardly surprising that so many Chapman design projects use one of the most versatile of all design materials: steel. A few examples are shown above. Cold-rolled steel gives durability and handsome form to the "hatbox" vacuum cleaner. The one-piece stamped steel faceplate on the home intercommunication system is treated with *three* different finishes (vinyl-clad steel is used on a more deluxe office unit). Stamped steel is used throughout the oil furnace burner for durability, and welded steel tube does double duty in the fuel nozzle where it must withstand both heat and pressure. For a hard, smooth, wearable surface, chrome plated steel is used on all the major work surfaces of automatic mail openers and addressing machines. Both formed steel and steel weldments are used to give durability and pleasing appearance to the combine harvester-thresher. The supermarket refrigeration case depends entirely on steel to stand up under rugged, daily wear, and to give it consumer-attracting style. The moral: no other material can match steel's ability to offer the designer the freedom of designing both functionally and aesthetically.

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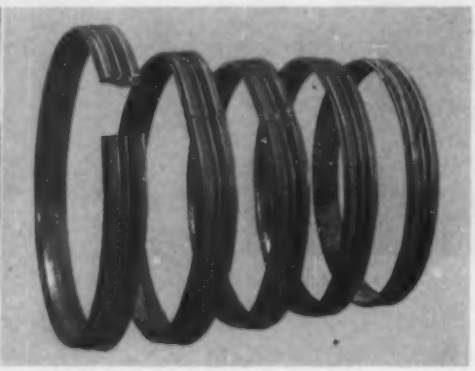
USS TRADEMARK United States Steel

This mark tells you a product is made of modern, dependable Steel.

Four problems solved by USS Design Steels

There are over 10,000 grades of steel in existence today. Good designers know that they can get a steel meeting practically any set of requirements and get maximum use of the inherent characteristics of the steel used. Here are four examples of special steels solving difficult problems. Each solution resulted in savings of weight, cost, and fabrication or erection time.



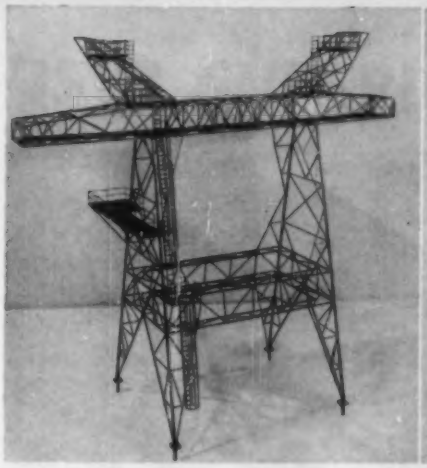
Bar becomes a ring in easy steps, 5 of which are shown here . . .
(1) circling the piece,
(2) form for welding,
(3) flash butt welded,
(4) rolled to shape,
(5) sized.

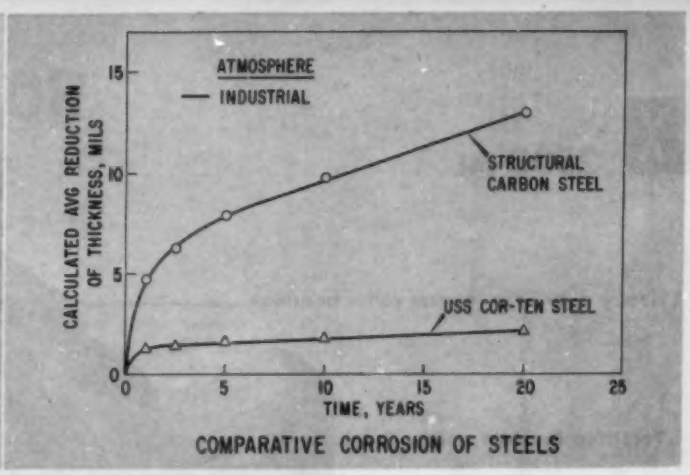
USS Special Sections strengthen earthmover wheel rims

The wheel rim of this giant earthmover is made from four special steel sections supplied by United States Steel. The rings are formed from special bar shapes rolled to an approximate cross section. This process eliminates many machining operations, saves steel, prevents large scrap losses and means fast production of a superior product. Special Sections are used because they result in straighter pieces and eliminate lateral camber. They give more uniform contact between the gutter section and the locking ring (another USS Special Section). Hot rolled USS Special Sections have great strength and excellent surface, so in most cases the only secondary steps needed are drilling, plating, and tapping before the part is finished. There is a wide range of USS Special Sections available in carbon, stainless, high-strength low-alloy, and heat-treated constructional alloy and armor steels, and custom-designed special sections can be made available. Write for our booklets, "USS Special Sections" and "USS Quenched and Tempered Structural Shapes."

From USS Ferrolite tin-coated steel, 40% more cans

USS FERROLITE tin plate was introduced by U. S. Steel in 1960. It is a new, thinner, yet strong, tin plate that produces 1400 six-ounce citrus juice cans compared with just over 1,000 cans formerly made from the same weight of conventional tin plate. (Incidentally, USS researchers haven't stopped there. Can designs have already been developed that use considerably less steel than is needed in conventional cans.) USS researchers are constantly adding new steels to the family of over 10,000 steels. FERROLITE tin plate is one of them.





COMPARATIVE CORROSION OF STEELS

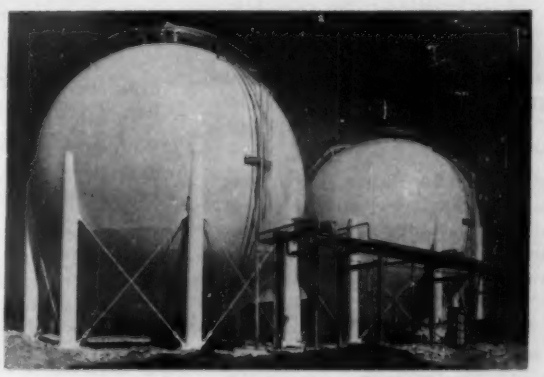
New transmission tower fabricated completely from bare USS Cor-Ten High-Strength Low-Alloy Steel

Near Pittsfield, Massachusetts, a prototype power system has been set up to study problems in extra-high-voltage transmission. This new outdoor laboratory, called Project EHV, is being used to study EHV problems at 360 kv to 750 kv. Eventually, the 4.3-mile system will become a power carrying segment of a New England electric utility system. Eighteen transmission towers are in the line. In most of them, conventional design is used. They are built of USS MAN-TEN high strength steel in combination with A7 carbon steel. But one tower is different. It is completely fabricated from uncoated USS COR-TEN High-Strength Low-Alloy Steel, and is the first of its kind to be installed in a transmission line. USS COR-TEN Steel is 50% stronger than structural carbon steel and is also four to six times more resistant to atmospheric corrosion. The tower will never be painted, because USS COR-TEN Steel develops a hard, tight-adhering oxide coating that forms an extremely tight seal against further corrosion, thus making possible a significant maintenance advantage. It's a design idea that can save any utility thousands of maintenance dollars in the future.

USS "T-1" Steel cuts pressure vessel weight 50%

These two pressure vessels have a capacity of 8,750 barrels of anhydrous ammonia. They are 45.5 feet in diameter and each shell weighs about 311,350 lbs. They were designed with USS "T-1" Constructional Alloy Steel, to an allowable working stress of 32,400 psi, so plate thicknesses were reduced to 1.109 and 1.075 inches. This is about 50% less than if A212-Grade B fire box quality steel had been used. Result: only 363 tons of USS "T-1" Steel were needed for both tanks, and thus freight, handling, welding and erection costs were less. Plates of USS "T-1" Steel, 78 and 115 inches wide and up to 19 ft. 2½ inches long, were shaped cold and field stress-relieved. Some shell plates and column plates were stress-relieved in the shop. Field welding electrodes were low hydrogen type of the E-110 strength level and all field welds were 100% radiographed.

USS "T-1" Steel has a minimum yield strength of 100,000 psi. It is tough, easily welded, and has excellent impact abrasion resistance. Use it to save money and time, to improve products.



For further information on any of these products, write United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

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USS United States Steel

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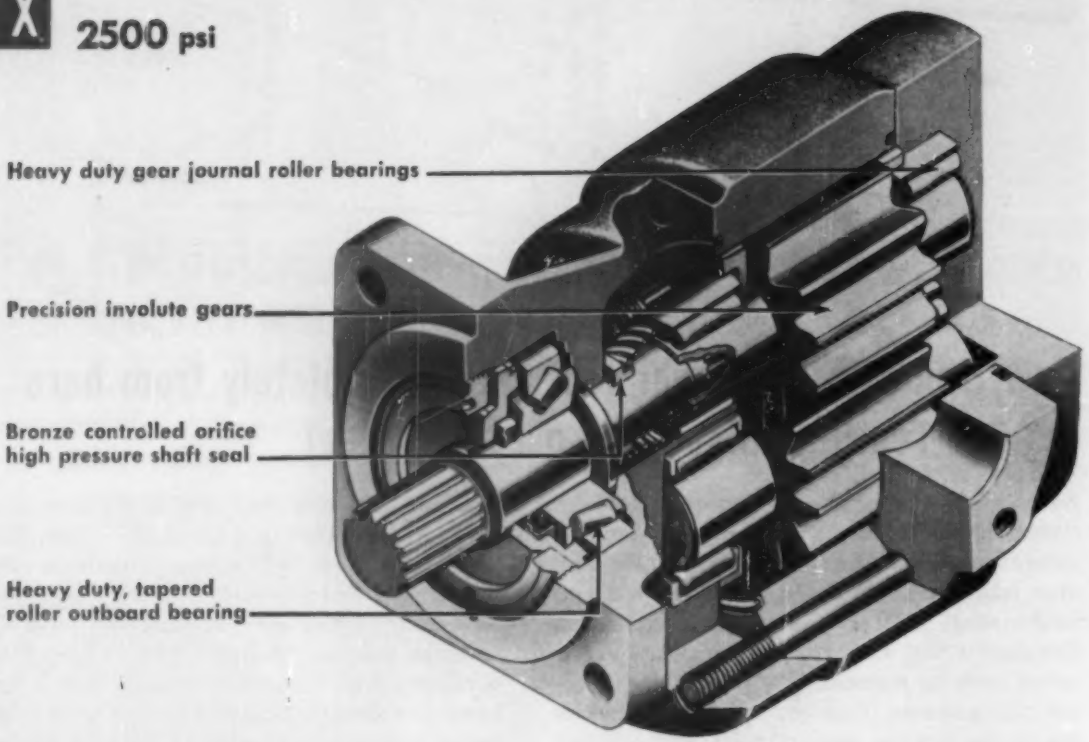
37X 2500 psi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Heavy duty, tapered roller outboard bearing

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Now Available—All new heavy duty COMMERCIAL constant displacement pump, Model 37X...recommended for 2500 psi continuous duty operation . . . sizes deliver from 11 to 56 gpm. Life expectancy better than 2:1 over previous models. Very simple is its breakthrough success secret . . . advanced design, new specification standards, rare craftsmanship and superior performance.

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Your Benefits:

1. You can design for higher pressure hydraulic circuitry for faster operation of your equipment.
2. Your fluid power generator will be more dependable, require less maintenance, have greater life expectancy.
3. Plus, the freedom of COMMERCIAL'S exclusive "COMPONENT GROUPED DESIGN" retained to permit tandem assembly up to 6 pumps on one shaft; total gear width not to exceed 6 in.
4. A competitive edge to meet today's more demanding performance required of your heavy duty construction, mining, materials handling, agricultural or ground support equipment.

Model 37X pumps are furnished with standard gear widths ½", 1", 1½", 2" and 2½".

performance data (per inch of gear width)

	delivery (gpm)		
speed rpm	500 psi	1500 psi	2500 psi
600	7	6	6
900	11	11	10
1200	16	15	15
1800	24	23	23

	input (hp)		
speed rpm	500 psi	1500 psi	2500 psi
600	3	7	13
900	4	11	19
1200	5	16	26
1800	6	23	38

Free bulletin gives mounting, piping and shaft data. Address: Commercial Shearing & Stamping Company, Department S-43, Youngstown 1, Ohio.

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CAPILLARY TUBING

in long lengths to 3000 ft.

Superior has devoted years to the development of manufacturing processes and quality-control procedures for the production of close-tolerance capillary tubing. ODs range up to 3/16 in., IDs from .004 through .040 in., lengths up to 3000 ft. Analyses include Types 304, 316, 321, 347 and 446 stainless; also Monel,[1] Inconel,[1] nickel and carbon steels.

[1]Reg. TM International Nickel Co.

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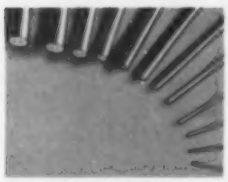

Superior supplies both tubing for one side of the "bridge" and for sheathing. Constantan and ingot iron are most frequently specified for one leg of the couple and stainless steel, Hastelloy C,[1] A Nickel,[2] Inconel,[2] Monel,[2] and 30% cupronickel for the sheaths. Superior tubing for thermocouples is usually supplied in the annealed condition to facilitate subsequent forming and machining operations. Other tempers from dead-soft annealed to full hard-drawn are available, if required.

[1]Reg. TM Haynes Stellite Co. • [2]Reg. TM International Nickel Co.

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Superior Tube

The big name in small tubing

NORRISTOWN, PA.

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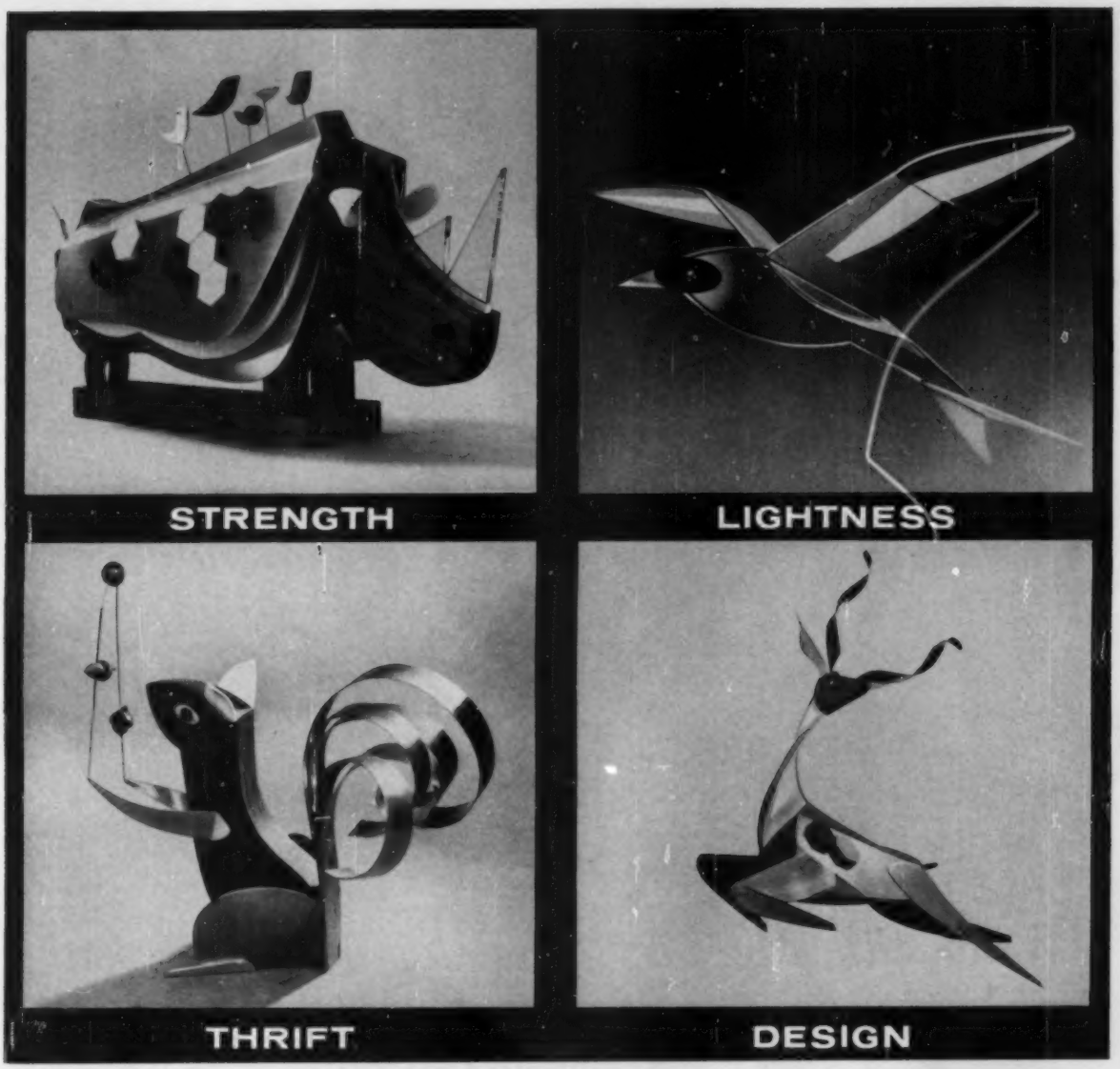

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LIGHTNESS adds appeal! 3M Adhesives increase product appeal, save freight and handling costs, help take pounds off today's metalworking products. They eliminate mechanical fasteners, increase the strength of a lightweight assembly by distributing stresses evenly over a wide area.

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ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

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3M COMPANY

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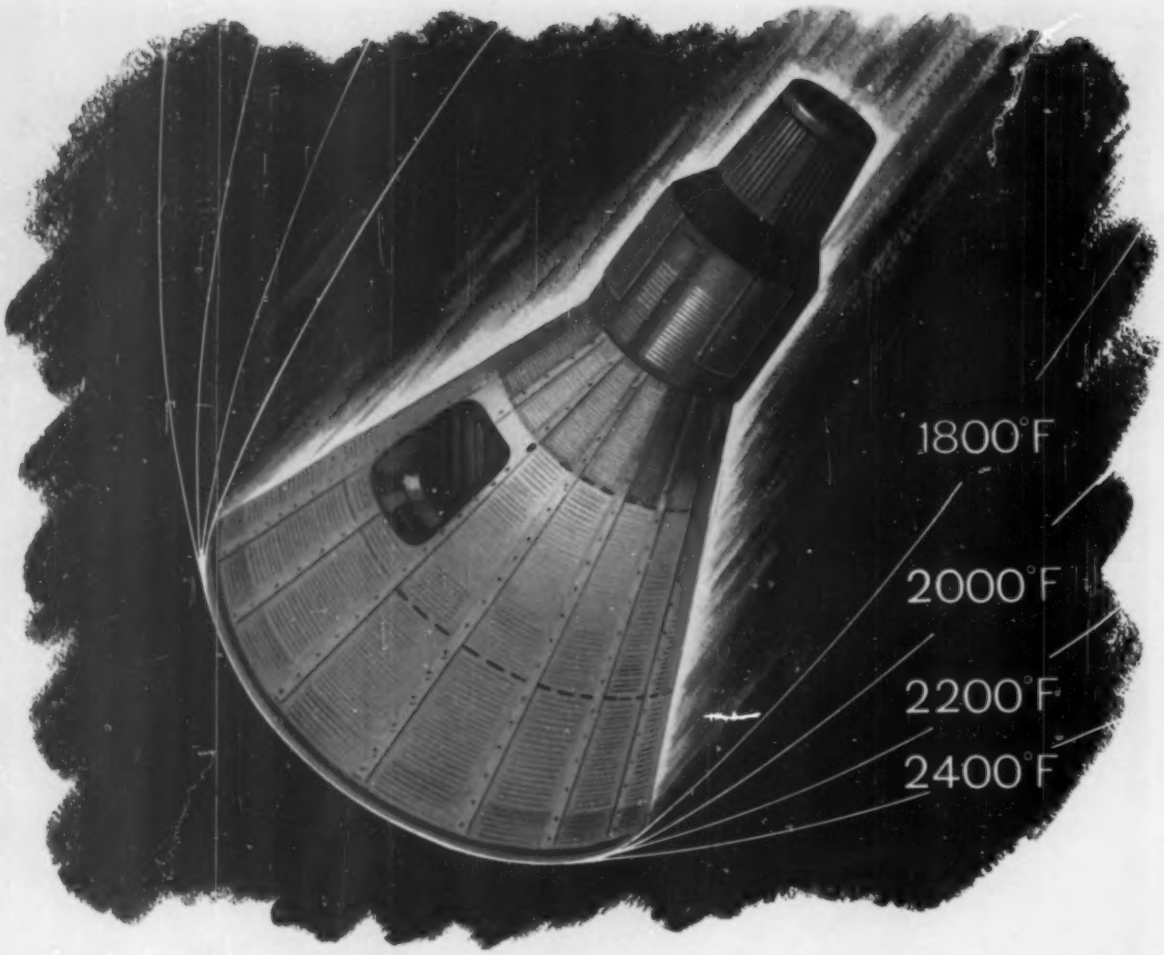

When this Mercury falls—temperatures soar!

Project Mercury engineer, in an Astronaut's pressure suit, with prototype HAYNES alloy-clad space capsule.

Whirling into re-entry from outer space, NASA's Project Mercury manned orbital space capsules must face a violent temperature rise. To protect the rear body walls from the terrific heat—plus violent erosive forces of the air—two alloys, produced by Haynes Stellite Company, were among those selected by the capsule builder. Rolled into thin sheet, these alloys dissipate the frictional heat by radiation outward into space—even as they maintain ample structural strength and outwit erosive attack.

HAYNES alloys that resist temperatures of over 2000 deg. F.—for long periods and under great stress—today serve in many hot spots. Resistance to stress, thermal shock, erosion, corrosion, and fatigue makes these alloys extremely useful in jet engine turbine wheels, in ramjets, missiles, rockets, and manned space capsules.

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Address inquiries to Haynes Stellite Company
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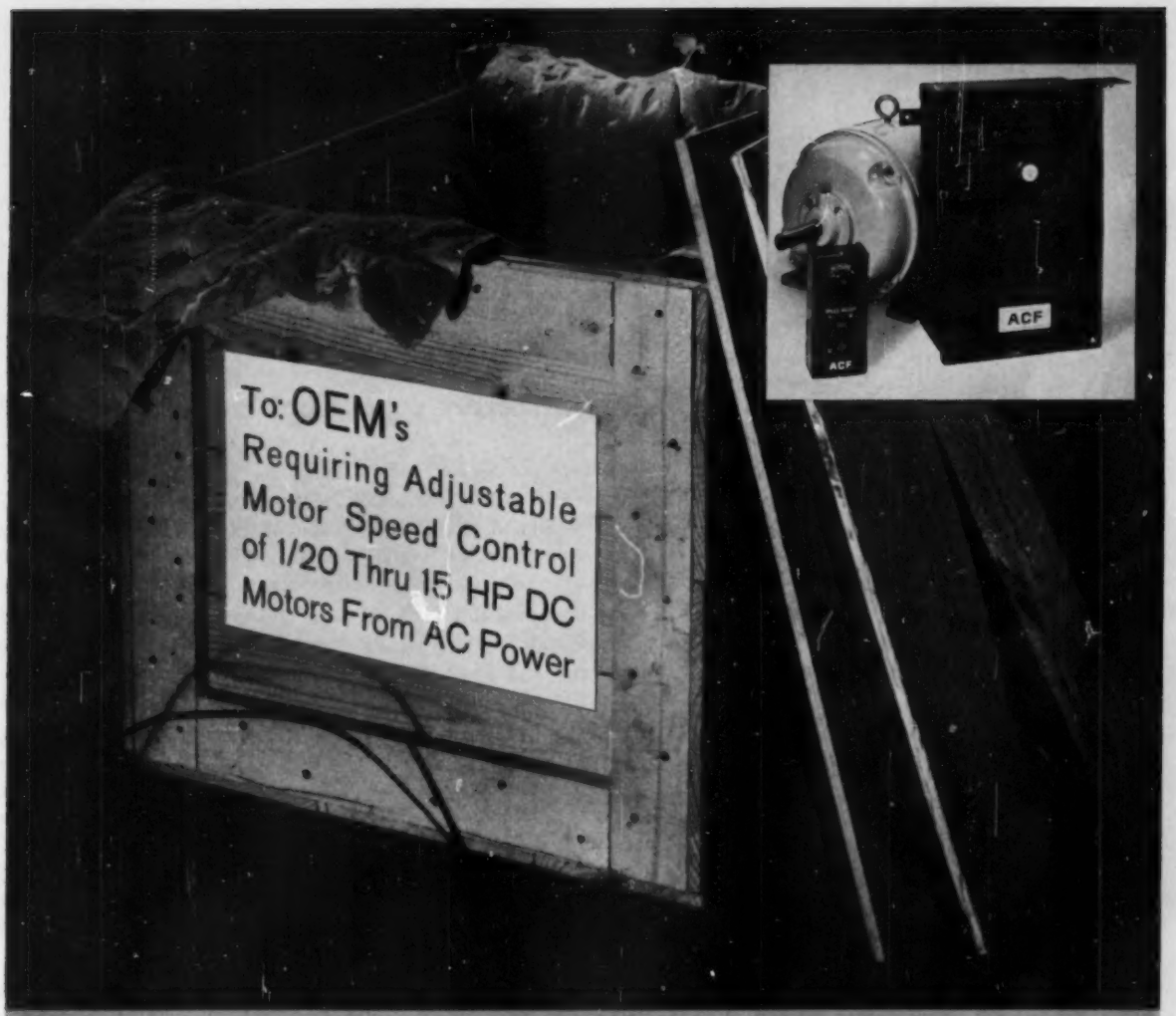

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ACF STEPLESS MOTOR CONTROLS, operating from an AC source, are smaller, lighter, more economical than competing systems—give smooth, precise regulation over a wide range of speeds regardless of load variations. ACF drive systems, for both fractional and integral HP operation, are available as off-the-shelf items. For full information, write or call Paramus Plant. 11 Park Place, Paramus, N. J., telephone: COlfax 1-4100.

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McGILL® specialized bearing engineering saves time and improves product design

McGill engineering, in the field and at the factory can save valuable time for you and help improve the design and performance of your products. McGill engineers are specialists in bearing application engineering. Matching their capabilities with your own product design will insure increased product performance.

The best time to coordinate these efforts is in the early stages of product design. Here, McGill engineers can offer their experience with thousands of successful applications when it can be most easily and profitably applied to your new designs. Alterations in both bearing and product can be made and tested more economically through progressively improved prototypes.

Whether the final bearing is standard or special, McGill will supply the proper configuration. Specially engineered bearings shown here are just a few examples of McGill creative bearing engineering. Each is the successful result of close cooperation between bearing and product engineers—from the beginning. You can profit too, by calling a McGill bearing engineer in early.

An indication of the creative design latitude of McGill bearing engineering is shown in the illustration. • Double row caged-roller—helicopter main transmission bearing. • Full-complement needle bearing with integral stud and outer race in form of grooved pulley wheel. • Special ball bearing with integral stud and special outer race used in press spacer application on punch press. • Ball bearing with special triple lip seals. Used as main hanger bearing on disc harrow. • Self-aligning, (two sections) stainless steel bearing. Used with hydraulic cylinder in missile aileron actuation. • High precision thrust bearing for hydraulic pumps. • Double row caged thin section needle bearing. Used as spindle bearing in automatic screw machines. • Thin section ball bearing used in magnetic clutches. • Full complement needle bearing with concave OD. • Needle bearing with center-guided rollers, special outer race with 7 flat surfaces.

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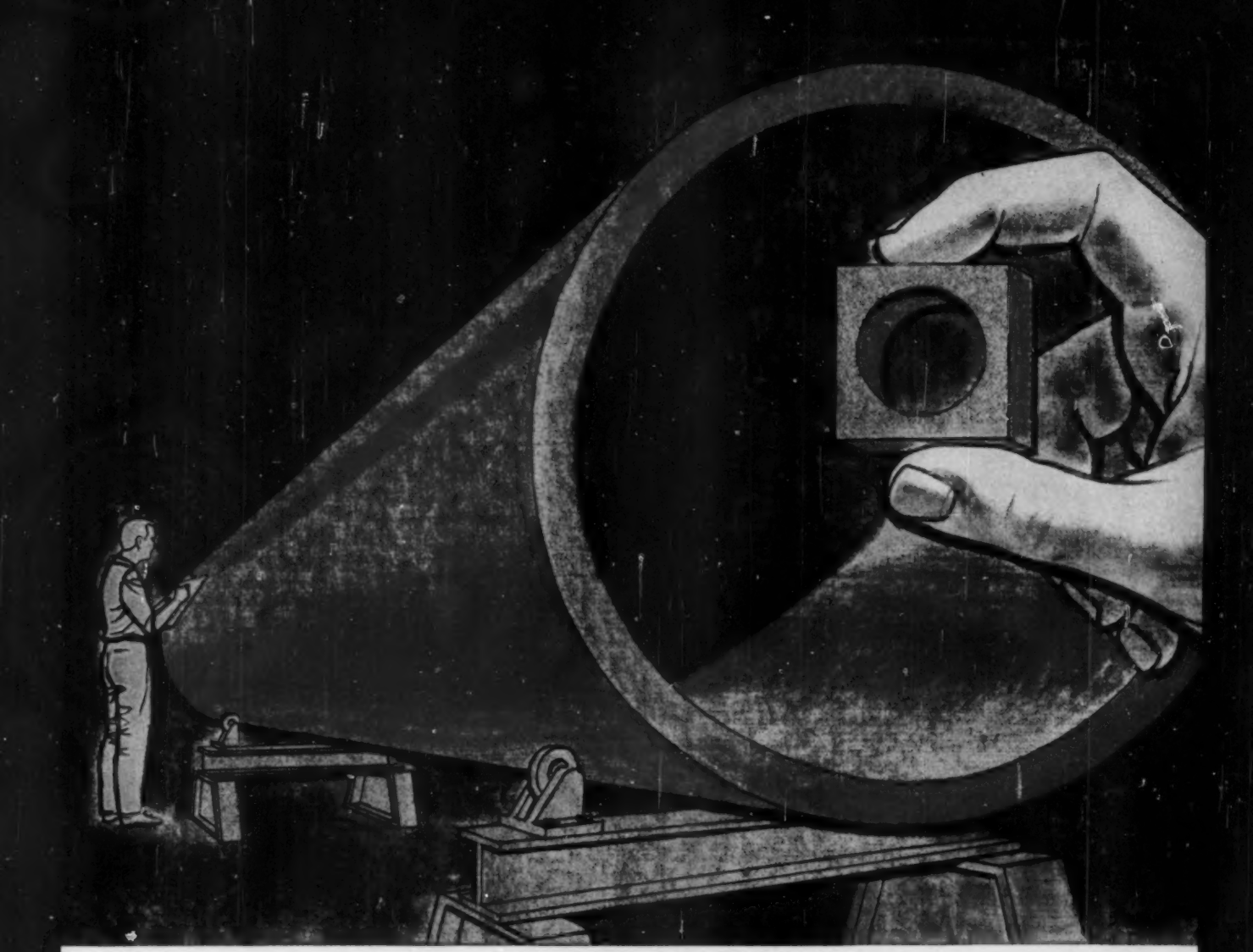

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From tiny liners and bushings to the largest sleeves, rings and rolls, you'll find that ferrous or non-ferrous symmetrical parts will be cleaner, denser and more uniform if they are centrifugally cast in Shenango's modern foundry. This means you'll save money. There will be less metal wasted, less machining time, fewer rejects and longer product life than would be true with ordinary casting methods. And because Shenango operates one of the biggest and most efficient centrifugal foundries and machine shops in the country, your largest orders will be filled quickly and exactly to specification. Write for literature.

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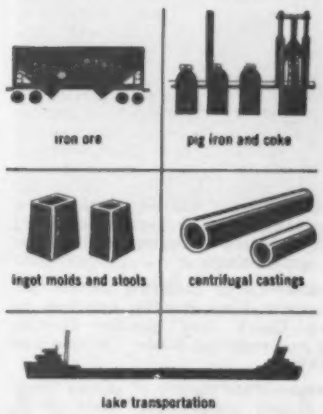

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OEM Guide to Electric Heaters

How to select the exact heating element to meet your product requirements

Here's condensed information from General Electric to help you get the most economical heater for your products.

CARTRIDGE HEATERS

• **Applications**—Efficient, self-contained heaters, for use singly to provide a "spot" of heat, or grouped to heat larger surfaces. Perfected for use in process machinery and for localized heating requiring close thermal control: dies, platens, molds, extrusion and injection barrels, gluepots, compound pots.

• **Features**—Durable nickel-chromium resistance wire packed in insulation and sheathed in metal tube.

• **Ratings**—30 to 2800 watts—Sheath temperatures: brass (750F); nickel-silver (1000F); chrome-steel (1200F)—Over-all lengths: 1½ in. to 2 ft.—Diameters: ⅜ in. to 1.293 in.—115v to 230v.

IMMERSION HEATERS

• **Applications**—Offer clean, economical method of heating various liquids in tanks, kettles, jackets and other containers. Suitable for immersion in water, oil, alkaline solutions, nickel, copper, chrome, plating solutions, mild sulphuric acid baths and salt baths.

• **Features**—Long life—Easily installed—Easily controlled—Sealed terminals—Excellent insulation and heat conduction.

• **Ratings**—Both through-the-side and over-the-side models available—Sheath materials: copper, nickel-silver, stainless steel, Inconel and lead—115v to 230v—Wide variety of models from 650 to 10,000 watts.

FIN TUBULAR HEATERS

• **Applications**—Especially suited to forced-convection air heating applications, such as air ducts with forced-air circulation, blower-type electric unit heaters, car heaters, recirculating ovens, industrial processes requiring heated air blasts for drying, baking, testing or pre-heating.

• **Features**—Large radiating surface per unit length—Fins sturdily attached by brazing—Quick heat transfer—Nonoxidizing rust-resistant finish—Durable construction.

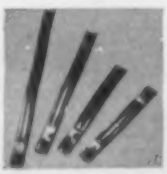
• **Ratings**—Wide variety of shapes available—Sheath temperature: steel (850F)—Watts: up to 100 per linear inch.

TUBULAR HEATERS

Applications—Applicable to practically every low-temperature (1500F or lower) requirement, whether heating liquids, air, soft metals, or metal surfaces. Typical applications: ovens, ducts, platens, pipes, space heaters.

• **Features**—High-quality resistance wire, insulated in metal tubing—Heaters bent to conform to almost any shape, cast into metal, located in drilled holes, grooves, or spaced away from surfaces.

• **Ratings**—Standard ratings, 500 to 5000 watts; special ratings available—Sheath materials: steel (750F); nickel-silver (1000F); stainless and Inconel (1500F); copper (212F in water).



STRIP HEATERS

• **Applications**—Designed for direct clamping to surfaces. Typical applications: process machinery, drying ovens, matrix scorchers, warming tables, glue tables, water baths, drying cabinets, pipelines, incubators, valve and pump houses, telephone switchboards, roll heating, packaging machinery.

• **Features**—Uniform heat distribution—Corrosion-resistant sheath materials—Easy to install—Moderate cost—Uniformity.

• **Ratings**—Provided with offset terminals at one end or terminals at each end—Sheath materials: Aluminized-steel (1000F); Chromized-steel (1200F).

METAL-MELTING HEATERS AND POTS

• **Applications**—Feature cast-in immersion heaters for melting lead, babbitt, tin, solder, type metal and similar metals up to 950F. Applications: dip soldering of subassemblies, railway and repair shops, electric service shops, printing plants, manufacturing plants, remelting metals.

• **Features**—Heat generated right in metal for quick heating, low radiation losses—Heater easily replaced without interrupting production—Reliable, safe, economical—Can be tied in with automatic temperature control.

• **Ratings**—Standard melting pots—Wt. 50 to 2000 lbs—Watts: 750 to 30,000.

OVEN HEATERS

• **Applications**—Designed for such applications as baking, japan, foundry cores, drying, low-temperature drawing ovens, and for general air heating applications in which there is free movement of air by convection. Heaters used in recirculating type ovens for core baking, paint drying, tempering, air heating in ducts, placement inside oven.

• **Features**—Easily mounted on side walls of oven or in ducts—Wide range in heater ratings and combinations of heaters.

• **Ratings**—Temperatures: Two models available: 750F–1000F, and up to 1200F.

VANE-TYPE HEATERS

• **Applications**—Used for air and surface heating applications: baseboard heaters, pipe heating, platen heating, valve and pump heating, drying cabinets and ovens, process machinery, compound tanks.

• **Features**—Rugged tubular construction resists mechanical shock and vibration—Large, 1¾ in. wide radiating surface—Low heat density: 25 watts per linear in. of vane; 14.3 watts per sq. in. of heater surface—Can be easily formed—Convenient mounting holes.

• **Ratings**—Variety of models from 500 to 2500 watts—115 to 230 volts—Over-all lengths: 24 to 104 inches—Maximum operating temperature 750F.

FREE New Catalog of General Electric Calrod* Industrial Heaters and Devices

• **Complete information** on these and many other G-E heaters and devices and control.

• **Easy-to-use application data**—New charts, tables, and guides make it easy to select just the right product for any application.

For your new catalog, write today to Section 757-02, General Electric Company, Schenectady 5, N. Y. Ask for GEC-1005.

*Reg. Trade-mark of General Electric Co.

GENERAL ELECTRIC

You can get high reductions with Gleason HRH* gear sets

This thirty-one-inch gear and its pinion have a 150 to 5 ratio. Yet they are hypoids — what we call HRH or high reduction hypoids.

These compact, flexible sets can be built to ratios as high as 360 to 1 without losing the traditional advantages of Gleason design proportions.

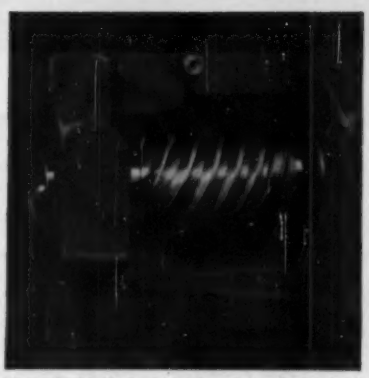
They permit you to design to tight space limits, particularly on big jobs.

They have a typically fine Gleason surface finish, impossible to get with hobbing or other methods. The pinion teeth *wrap around* the pinion, so you get continuous tooth action even with a one-tooth pinion. The resulting motion is always smooth and continuous.

You use regular Gleason machines to manufacture these gears . . . in small quantities and large.

And with all that you get the usual complete technical assistance from our engineering staff . . . all the way through the design stages on to prototypes and full production.

Find out what HRH gears can do for your transmissions by contacting us directly.



The cylindrical shape of the pinion lends itself readily to straddle mountings. The high offset design also increases the diameter of the pinion, lending extra strength to the entire assembly.

*Trademark for Gleason High Reduction Hypoids

GLEASON WORKS

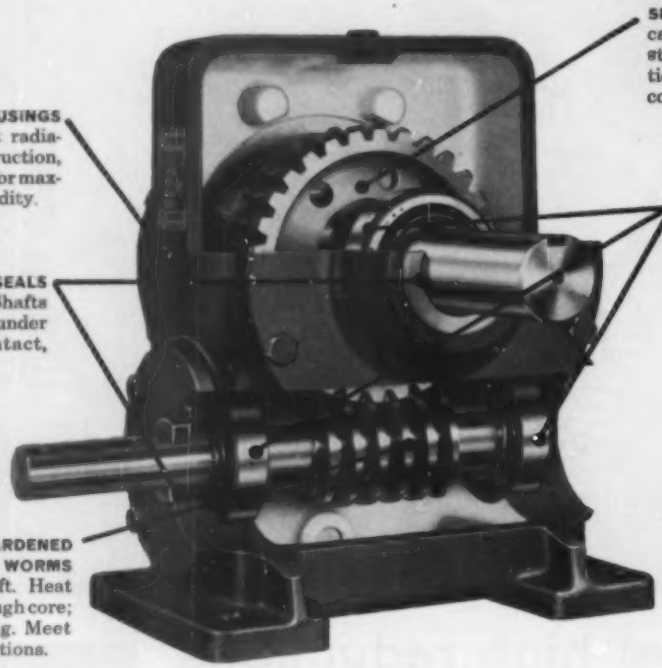
1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

Circle 246 on Page 19

Engineering Data

WINSMITH SPEED REDUCERS

WINSMITH "C" SERIES WORM GEAR SPEED REDUCERS



SPECIAL BRONZE WORM GEARS cast to recommended AGMA standards. Low coefficients of friction and thermal expansion for cooler, more efficient operation.

CAST IRON HOUSINGS designed for high heat radiation. One-piece construction, close-grained gray iron for maximum strength and rigidity.

TAPERED ROLLER BEARINGS for minimum maintenance, long bearing life, permanent shaft alignment. Capacity to handle high radial and thrust loads.

POSITIVE OIL SEALS keep oil in, dirt out. Shafts lapped to micro-finish under seals for uniform contact, longer seal life.

AVAILABLE in single and double reduction models, for intermittent or continuous service. Order from stock with right-angle or parallel shafts, worm on top or bottom, all worm gear or combined worm and helical. All types of special units also available.

CASE-HARDENED GROUND STEEL WORMS cut integral with the shaft. Heat treated for close-grained tough core; carburized before grinding. Meet AGMA long-wear specifications.

- *108 Models*
- *1/100 to 34 H.P.*
- *Ratios 5:1 to 4460:1*
- *Max. Output Torque 142 to 34,767 in. lbs.*

Winsmith "C" Series Reducers are compact units which offer a wide range of horsepower and torque output in minimum space. Their design and construction provides high shock load resistance; maximum thermal capacity without induced cooling; greater overhung load capacity; all moving parts totally enclosed in a dirt-proof housing and lubricated from a central oil bath; and complete interchangeability of major components. These features add up to smooth, trouble-free performance—an extremely low rate of wear—high mechanical efficiency—and greater overall economy per horsepower dollar.

For complete information on Winsmith Speed Reducers, write today or call your nearest Winsmith Representative. You'll find one in every major industrial area, listed in the Yellow Pages. They are technically trained experts who are always ready to help you with any speed reducer problem. For both standard and special power transmission applications, you'll find it pays to standardize on Winsmith.

WINSMITH, INC.

202 Eaton Street, Springville, (Erie County), New York

MEMBER OF AGMA

• • • Winsmith Speed Reducers are made by American craftsmen to meet American design and production standards.

Circle 247 on Page 19

Circle 248 on Page 19→

working with

Du Pont Zytel®

one of Du Pont's versatile engineering materials

Fuel regulator molded of ZYTEL® NYLON RESINS

is lower in cost, lighter in weight, easier to install

You might well ask, "lower", "lighter" and "easier" than *what?* The answer: *than automotive fuel-pressure regulators constructed of metal or glass and metal.* This new fuel regulator, which controls the pressure of gasoline injected into the carburetor, has three major parts precision-molded of Du Pont ZYTEL nylon resin . . . eliminating the expensive machining and finishing operations usually associated with metal regulators. Hence, cost is lower. Molded in ZYTEL, the regulator weighs only 2 oz., eliminating the need for metal clamps or other fittings. The new unit installs without adaptors to any gas line by inserting ends of the opened line into bushings pressed into the unit.

Key to the selection of ZYTEL for this exacting application is the combination of properties offered by these resins: high mechanical strength and resistance to gasoline and petroleum products at high engine temperatures.

The Miser-Mite fuel-pressure regulator is molded by Artag Plastics Corp., Chicago, Ill., for Milemaster, Inc., Exeland, Wisconsin.

On the next page you will find more examples of how the properties of ZYTEL nylon resins are being used to improve the design and performance of products in a variety of fields.

DU PONT

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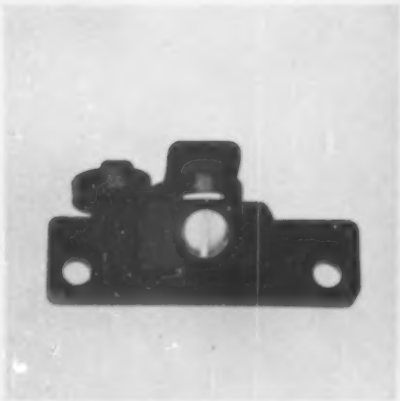
BETTER THINGS FOR BETTER LIVING ... THROUGH CHEMISTRY

working with

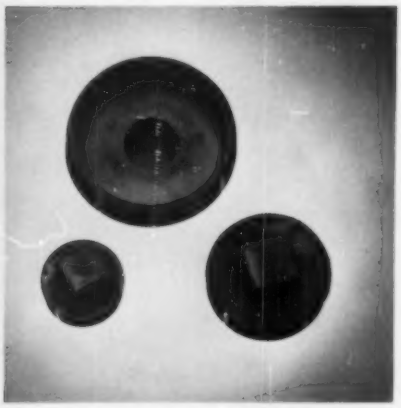
Du Pont Zytel®

one of Du Pont's versatile engineering materials



Electric motor brush holder used in an improved electric impact wrench is a one-piece molded part of ZYTEL, providing excellent electrical insulation properties, wear resistance and high strength. Cost, including parts and assembly time, is 65% less than the three-piece fabricated brush holder assembly previously used. Molded by Amos-Burke Plastics, Inc., Syracuse, N. Y., for Chicago Pneumatic Tool Company, Utica, N. Y.

Swivel chair hub liner molded of ZYTEL® eliminates necessity of lubricating center spindles, maintains a wobble-free, tight fit through long periods of use. ZYTEL nylon resin was selected for its low coefficient of friction, resistance to impact and abrasion, and close molding tolerances. Molded by Nylon Products Corp., affiliated with F. J. Kirk Molding Co., Clinton, Mass., for Collier-Keyworth Company, Gardner, Mass.



Removable cleanout plug allows cleaning of sewage drainpipes. Molded of ZYTEL, the plug can be removed easily time after time, does not stick—because ZYTEL nylon resin resists the accumulation of mineral deposits from water. Quick, accurate injection molding eliminates need for sand casting and thread machining required by brass plugs. Coast Craft Industries, Glendale, California, for A. H. Voss Co., Los Angeles, California.

Three useful properties of ZYTEL® NYLON RESINS: high insulation... low friction... good moldability

Depending on the particular application, different combinations of properties offered by ZYTEL nylon resins become crucial—as witness the applications discussed on this page and the preceding page. To evaluate the design opportunities offered by ZYTEL for your application, consider the entire range of properties offered by ZYTEL nylon resins, and the many different formulations of ZYTEL available. The coupon below will bring you pertinent further information.

POLYCHEMICALS DEPARTMENT

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.), Dept. 4
Room 2507Z, Nemours Building, Wilmington 98, Delaware.

Please send me: ☐ How 50 Manufacturers Used ZYTEL® Nylon Resins to Make Better Products — A
☐ Designing with ZYTEL® — B

I am interested in evaluating ZYTEL for_____

Name_____ Position_____

Company_____

Street Address_____

City_____ Zone____ State_____

Type of Business_____

In Canada: Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec

ZYTEL® nylon resins

Alathon® · Delrin® · Lucite®

new from Warner Electric

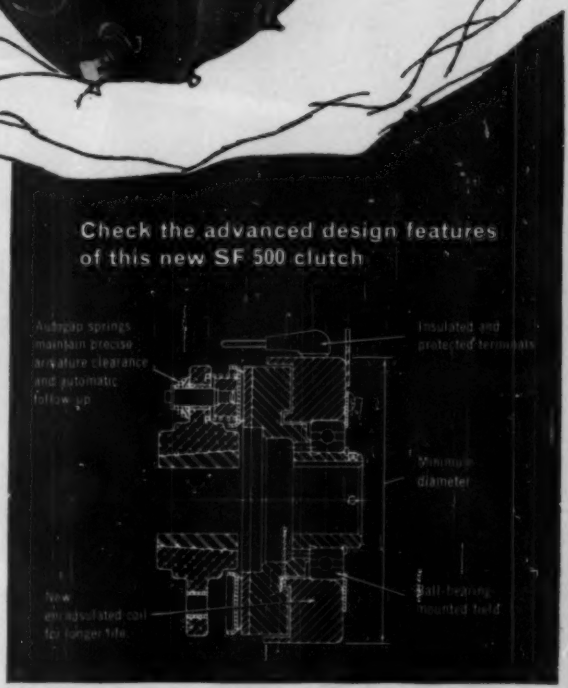
easier mounting, greater torque-for-size Electric Clutch

New Warner SF 500 clutch
Static torque rating—50 lb-ft

This new rugged and reliable Warner SF 500 electric clutch combines minimum size with maximum torque—up to 50 lb-ft static. It offers simplified mounting (no collector rings or brushholder) of the ball-bearing-mounted stationary field.

The new encapsulated coil delivers peak reliability, longer life under the severest operating conditions. Minimum axial dimension permits installation of the new SF 500 in smaller space than ever before possible—yet it replaces existing units without reworking or machining.

Improve *your* machine control economically, simply—with the new Warner SF 500 stationary-field clutch. It eliminates complex hydraulic, air, or mechanical linkages—gives you the simplest, most reliable control on the market today. Warner stationary-field electric clutches are now available in torque ratings from 1.5 lb-in. to 1350 lb-ft. Write today for full details.


Check the advanced design features of this new SF 500 clutch
Insulated and protected terminals
Minimum diameter
Ball-bearing mounted field

----WARNER ELECTRIC----

Warner Electric Brake & Clutch Co., Dept. MD-10, Beloit, Wisconsin

I'm interested in the new SF 500 clutch. ☐ Send me full specifications. ☐ Have a salesman call.

☐ Send data on complete Warner line of electric brakes and clutches.

Name_____

Title_____

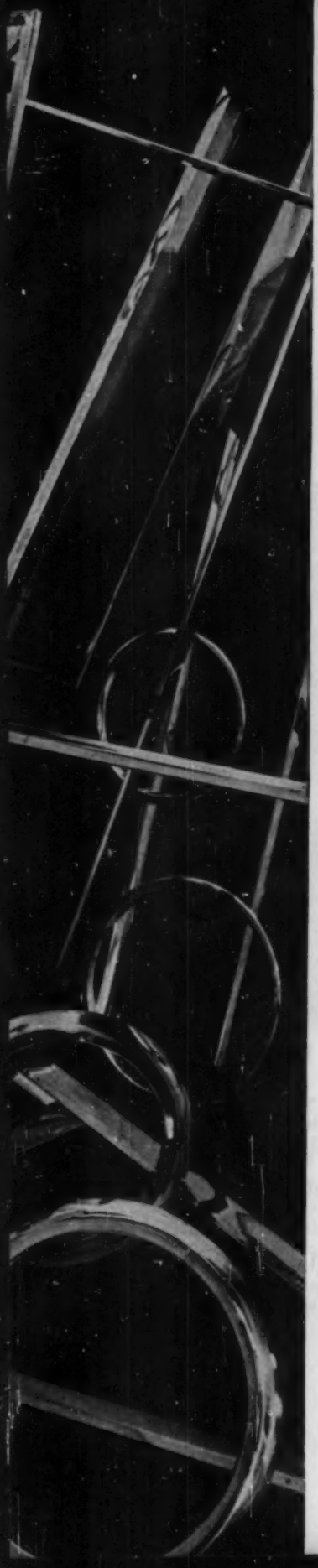
Company_____

Address_____

City_____ Zone____ State_____

Stocked by Authorized Distributors in Principal Cities Throughout the World

←Circle 248 on Page 19 Circle 249 on Page 19



This is an unretouched photograph of automotive and appliance trim formed of Sharon's bright annealed Stainless Steel. While it loses some of its sparkle in the advertising platemaking process, it gives you some idea of the brilliance of this new Stainless Steel. A detailed pamphlet has been prepared. Write for your copy today.

WHY DESIGNERS LIKE

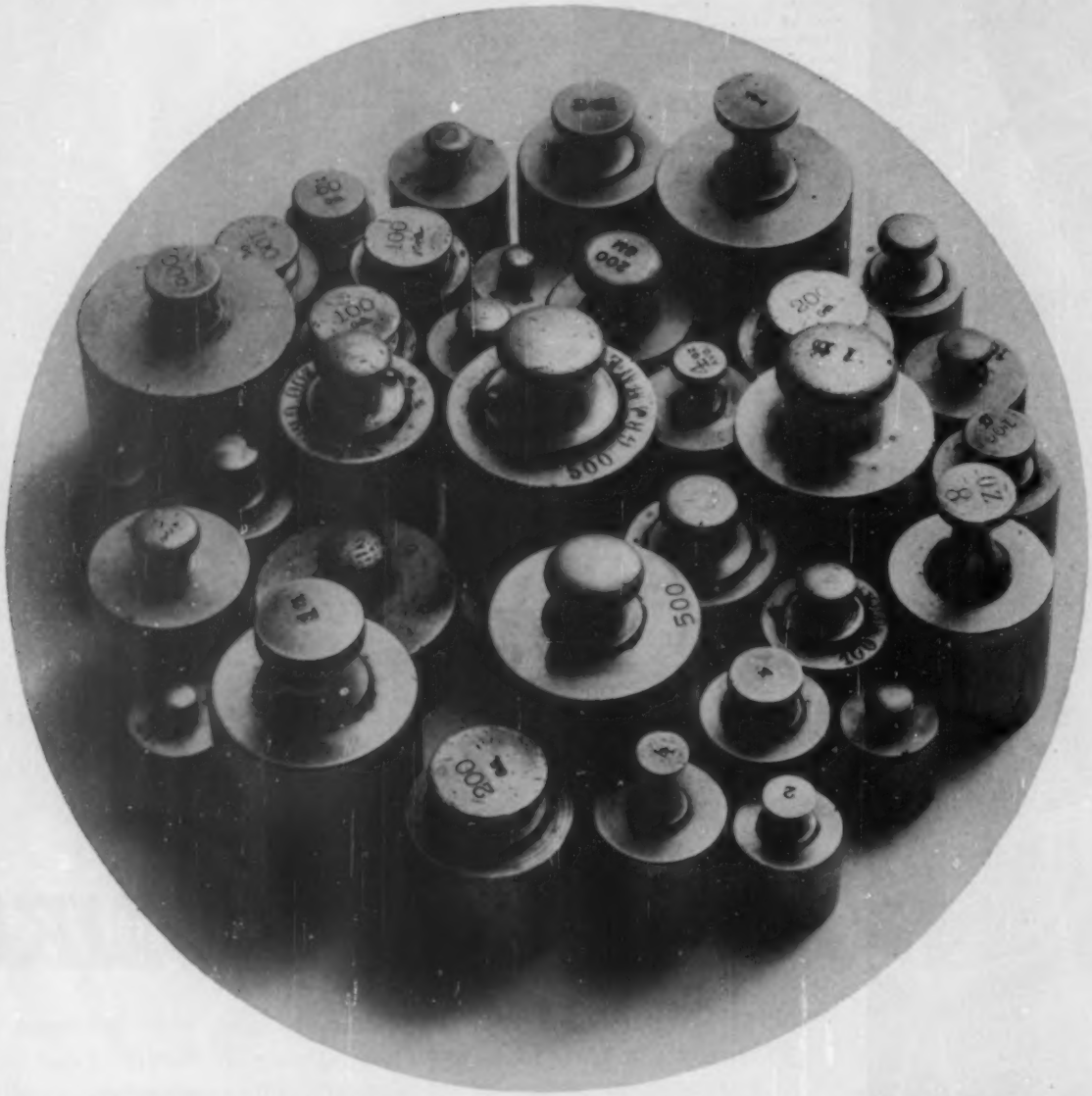
The brightest, most sparkling Stainless Steels ever developed are creating unusual excitement among manufacturers of our high-quality products. Automotive engineers, appliance designers, furniture people, architects and business machine makers, to name a few, are specifying Sharon *bright annealed* Stainless Steels to a greater degree than ever before. *Bright annealed* Stainless Steel is truly the best looking metal ever made. What's more, it has excellent forming characteristics and improved corrosion resistance, and it reduces or often eliminates buffing operations on high-finish parts. To accent and enhance the appearance of your products, think of the new *bright annealed* Stainless Steels, and when you do . . . think first of the *Sharon Steel Corporation, Sharon, Pennsylvania.*

SHARON *Quality* STEEL

AMERICA'S FOREMOST PRODUCER OF LIGHT STEELS

SHARONSTEEL®

Circle 250 on Page 19



Count different sizes and weights the easy way—with a Veeder-Root High Speed Magnetic Counter. *Once it was virtually impossible to record things* both large or tiny, heavy or featherweight with electric counters. Nowadays, Veeder-Root magnetic counters do it at high speed and deliver remote *readout data for centralized control. Design them into new machines* or use them on existing equipment. You'll find them compact, reliable, simple to install. Need details? Write Electrical Section, Veeder-Root Incorporated, Hartford 2, Conn.

count on...VEEDER-ROOT

FREE — a new bulletin on Series 1591 counters. Get key facts on how these electrically actuated counters report machine output from factory to office, and how they pay off on many other devices. Send for Bulletin 842.

Circle 251 on Page 19

Think Delivery . . .

HOLO-KROME'S SAME-DAY SERVICE ON THERMO-FORGED* SOCKET SCREWS PREVENTS DOWNTIME ON YOUR PRODUCTION LINE

Downtime costs profit dollars . . . that's why you've got to be sure the fasteners you vitally need arrive at your plant *on time*. And that's why Holo-Krome's Same-Day Service is so important to you. Packaged goods shipped *same day the order comes in*—most specials shipped in four weeks or less.

*Trade Mark of The Holo-Krome Screw Corporation

For profit-making quality and on-time delivery, standardize on Holo-Krome THERMO-FORGED socket screws. See your authorized Holo-Krome distributor or write for more information.

HOLO-KROME
Thermo-Forged*
SOCKET SCREWS

SOLD ONLY THROUGH AUTHORIZED HOLO-KROME DISTRIBUTORS
THE HOLO-KROME SCREW CORPORATION • HARTFORD 10, CONN.

Circle 252 on Page 19

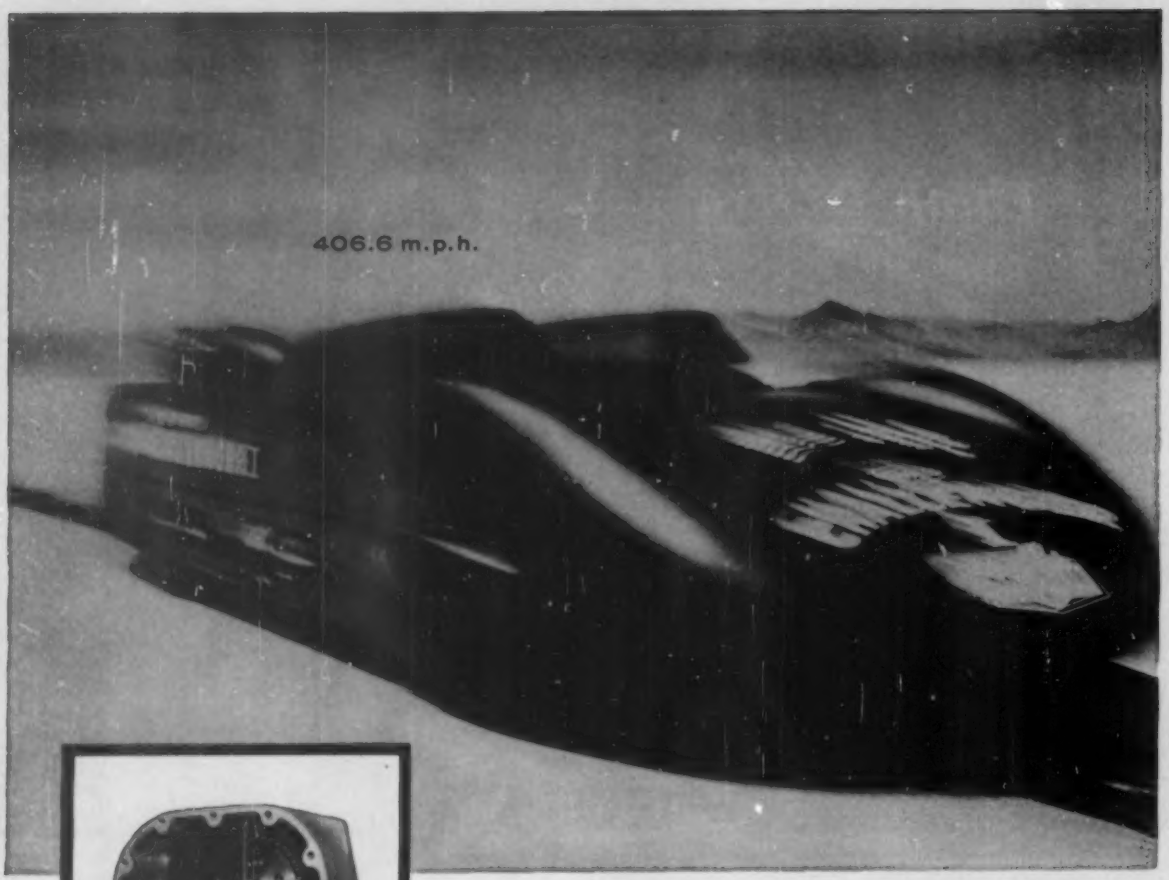
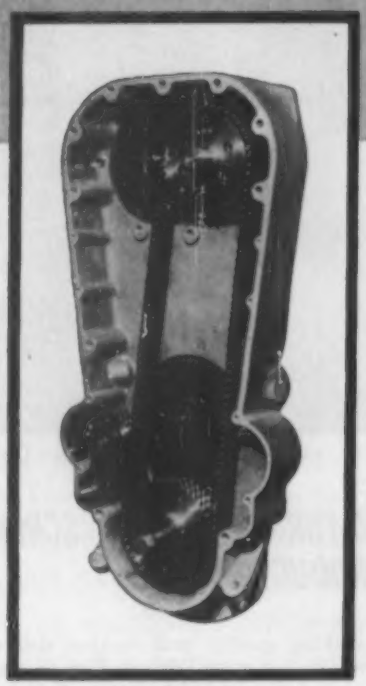


Photo courtesy Champion Spark Plug Co



The supercharger drive was designed and installed by Cragar Equipment Company.

look for the ◇ on the links

RECORD BREAKER

uses DIAMOND No. 35-3 Chain

When Mickey Thompson flashed over Bonneville Flats at 406.6 M.P.H. to set a new one way land speed record his "Challenger I" used four of these supercharger drives, one for each of the powerful 750 HP engines.

For championship performance like this, these Diamond 35-3, press-fit centerplate chains, only 1-5/16 inches wide, transmitted upward thru 90 HP. This power was flowing at one and one half miles per minute from the crankshaft to the superchargers, turning 6600 RPM.

DIAMOND gives you case hardened, precision built roller chains to withstand shock loads and high rotation speeds . . . and to insure maximum life and trouble-free performance.

For information on DIAMOND Roller Chain and Sprockets write for Catalog No. 760.

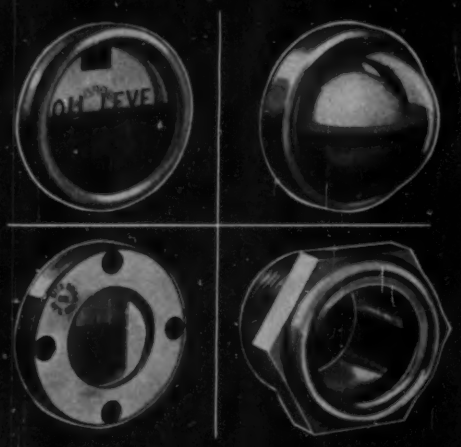
DIAMOND CHAIN COMPANY, Inc.

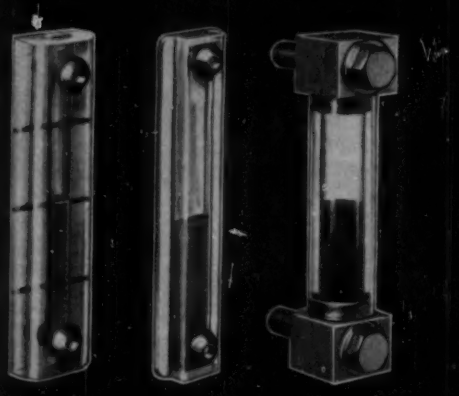
A Subsidiary of American Steel Foundries

Dept. 435 • 402 Kentucky Avenue • Indianapolis 7, Indiana

Circle 253 on Page 19

168 Gits view gauges





NEW DESIGNS, NEW GITS CATALOG GIVE YOU WIDEST CHOICE OF STOCK GAUGES

Your chances are excellent to find the gauge you need among the 168 styles and sizes described in Gits' new gauge catalog.

For example, the four window styles pictured here are stocked in all three mounting types, and in many sizes. Also, note the economical new column gauges designed for easy installation and high visibility. Gits' catalog also includes rugged brass sight-flow, column, and filler-type gauges and visual-feed oilers. For your new Gits View Gauge Catalog ask your Authorized Gits Distributor or send in this coupon.

GITS BROS. MFG. CO.

Circle 254 on Page 19

Please send your new Gits View Gauge Catalog.
We are interested in:

- ☐ Window Gauges
- ☐ Sight Flow Gauges
- ☐ Column Gauges
- ☐ Other _____

For use on:

Product _____

Media contained _____

☐ O E M ☐ Maintenance

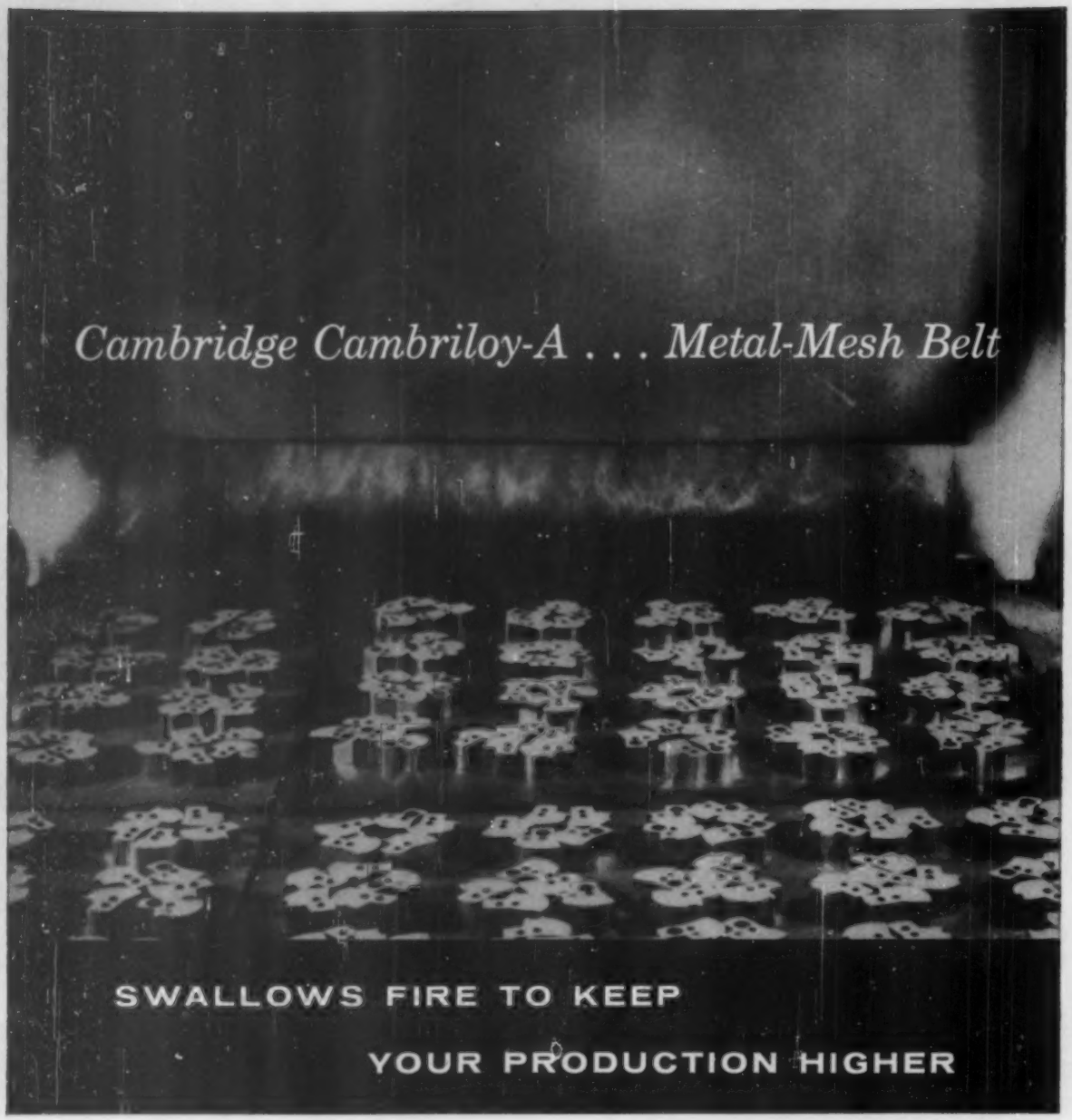
NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ STATE _____

Gits Bros. Mfg. Co., 1868 South Kilbourn, Chicago 23, Ill.



2100° F. sintering temperatures are no place for weakling belts. That's why so many sintering installations select Cambridge Belts made of Cambriloy-A alloy. They are specifically designed for high strength in high temperatures and resistance to murderous furnace oxidation atmospheres . . . built to give continuous month after month service and peak production with little or no maintenance.

There is a complete line of Cambridge Belts in special and standard metals and alloys to meet your specific requirements—custom built in any one of nine basic weaves to insure the most efficient processing.

Experienced Cambridge Field Engineers—experts in their field—are available to discuss your needs and help you select the belt best suited to your operations. Or, they can offer you sound advice on the installation, operation and maintenance of your Cambridge Belts. Talk to your Cambridge man soon. He's listed in the Yellow Pages under "Belting, Mechanical". Or, write for free 130-page reference manual.

The Cambridge Wire Cloth Co.

Department N • Cambridge 10, Md.

Manufacturers of Metal-Mesh Conveyor Belts, Flat Wire Conveyor Belts, Wire Cloth, Wire Cloth Fabrications, Gripper ® Metal-Mesh Slings

RSVP SUPERIOR

PRESSURE AND SUPER-PRESSURE TUBING

Keeps pressures controlled

Commercial pressure tubing for use in a range up to 20,000 psi; premium super-pressure tubing to handle pressures from 15,000 to 100,000 psi. Various analyses, depending on service conditions. Super-pressure tubing is available in single and composite wall types made to mechanical properties specified by customer. Size range: commercial pressure, ⅛ to ⅝ in. OD; super-pressure, ⅛ through ¾ in. OD.

RETURN THIS CARD FOR COMPLETE DATA

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

West Coast: Pacific Tube Company, Los Angeles, California

SUPERIOR TUBE COMPANY
Norristown, Pa.

Send me complete information on the following tubing:

☐ Pressure and Super-Pressure Tubing
☐ Carbon and Alloy Steel Mechanical Tubing
☐ Other _____

Name _____ Title _____

Company _____

Street _____

City, Zone, State _____

FIRST CLASS
Permit No. 9
Collegeville, Pa.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

POSTAGE WILL BE PAID BY—
SUPERIOR TUBE COMPANY
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RSVP SUPERIOR

CARBON AND ALLOY STEEL MECHANICAL TUBING

for many commercial applications

Seamless tubing with specific mechanical properties for your application. Held to extremely close tolerances. Supplied in many different shapes. Offered in three standard tempers and with bright, smooth surface finishes. Analyses include C-1008, MT-1010, Leaded C-1020, MT-1020, C-1025, C-1035, E-1095 and ingot iron. Also 4130, 4132, 4140, 4150, 8630 and 52100. Sizes range from .010 through ⅝ in. OD. Above ⅝ in. OD, max. wall is .035 in.

RETURN THIS CARD FOR COMPLETE DATA

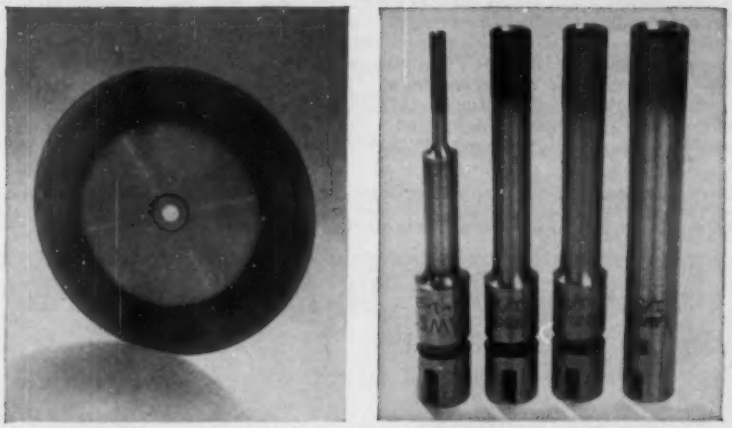
Superior Tube

The big name in small tubing
NORRISTOWN, PA.
West Coast: Pacific Tube Company, Los Angeles, California

Linde Coatings & materials News

LINDE COMPANY, DIVISION OF UNION CARBIDE CORPORATION

Long wear for precision cutting parts now comes in thin coatings—.001" thick



Two important industrial cutting tools whose working lives have been multiplied by LINDE Flame-Plating tungsten carbide coatings: Rubber skiving knives (l.) and paper drills.

SUPER-THIN coatings of tungsten carbide and aluminum oxide—in the .00075" to .002" range of thickness—now keep many industrial cutting surfaces on the job many times longer than previously, yet preserve the precision fit needed for optimum cutting. The result: important savings in downtime and operating costs.

These tough, long-life precision coatings are applied by LINDE's Flame-Plating process, which "blasts" molten particles of tungsten carbide onto specified areas of wearing surfaces until the particles are built up to the desired degree of thickness.

Typical examples of longer wear

Because their cutting surfaces are Flame-Plated with tungsten carbide ..ting, rubber skiving knives that for-..rly required resharpening after every shift now stay in use 15 times longer. The knives also have the advantage of a self-sharpening effect. As the softer steel base wears more rapidly than the hard, tungsten carbide coating, a sharp edge is always presented to the material being cut.

Tungsten carbide coating enables serrated knives used in cutting plastic sheeting to process three times as much material before the first re-sharpening is necessary.

A coating of .001" thickness on the inside cutting surface of surgical shears has reduced their rate of wear by as much as 33 percent.

Flame-Plating proved so revolutionary for household cutlery that the manufacturer built his merchandising theme around *"The Greatest Development in 2000 Years of Cutlery Making—a Cutting Edge of Tungsten Carbide."*

Solves many wear problems

Tungsten carbide coatings of microinches thickness are equally effective wherever metal parts or working surfaces are exposed to abrasion, galling, erosion, fretting, corrosion, or high-temperature wear. Coatings are applied by the LINDE's 6,000-degree Flame-Plating process without distortion of the work piece or changes in properties of base metals.

For full information on Flame-Plating for your particular application, check and mail the coupon below.

Need to production-polish tungsten carbide surfaces?

It's easy with LINDE metallographic production-polishing aluminas—available in grades for three types of finishing: For high stock removal, 1 micron C; for moderate stock removal and ¼ rms finish, 0.3 micron A; for super polish, 0.05 micron B.

LINDE has developed special techniques for production-polishing of semiconductors and soft metals (such as brass), also new ideas for production-polishing hard metals, including micrometer anvils, hardened bearing races, routine metallographic samples. Get help with polishing techniques to meet your requirements. Send coupon below.

Jet planes landed by ruby-against-sapphire wear pads

In the automatic landing computer of a modern jet interceptor, a tiny ruby ball held to tolerances of 30 millionths oscillates against a synthetic sapphire plate flat to 1/10 light band, as a reference plate for a computer to translate radar approach signals into hydraulic actions.

Approximate size: Ruby ball, sapphire plates.

A similar wear surface bears on the cam head. Certain fly wheel governors also have sapphire wear surfaces.

This 70,000 to 300,000 psi LINDE material has a hardness second only to diamond, unlubricated static friction coefficient of .18, and dynamic of .08 against itself in moderate loads. It is economically suited for wear applications such as gage points, textile guides, optical inspection flats, and flow valves. Send coupon for information.

CHECK—CLIP COUPON—ATTACH TO BUSINESS LETTERHEAD

Linde Company
270 Park Avenue
New York 17, N. Y.

Please send data on the items checked:

- ☐ LINDE Flame-Plating Process
- ☐ LINDE Alumina Abrasive Powders
- ☐ LINDE Synthetic Sapphire & Ruby

UNION CARBIDE

LINDE COMPANY

"Linde" and "Union Carbide" are registered trademarks of Union Carbide Corporation

Circle 256 on Page 19

Higher strength steels make more sense for this rugged, light-weight trailer

(It carries 1100 pounds more)

Here is a high-capacity dump body trailer that gives you a substantial dead weight reduction for only a few cents per pound of payload increase!

This trailer, which went into service in January, 1961, hauling both hot and cold slag, is proof that each pound of payload increase you buy can cost as little as 35¢ per pound.

To prove our point, this 27-cubic-yard trailer was created by the TEC Division of the Heil Company, Cleveland, Ohio, in conjunction with the Applied Research Laboratory of United States Steel. Using the USS Family of Steels—carbon steel, USS COR-TEN High-Strength Low-Alloy Steel (50,000 psi minimum yield point) and USS "T-1" Constructional Alloy Steel (100,000 psi minimum yield strength)—compared to a similar capacity carbon steel trailer, we were able to reduce the weight of this one by 1100 pounds—at a cost of only *35¢ for each one of the 1100 pounds.*

This was done by using 14-gage USS COR-TEN Steel for trailer body sides, 12-gage in the floor, and USS "T-1" Steel in the high-strength, lighter weight draft arms.

As a bonus, both USS COR-TEN and "T-1" Steels give you four to six times the atmospheric corrosion resistance of carbon steel. You also get high resistance to abrasion and impact. USS COR-TEN holds paints considerably longer than ordinary carbon steel.

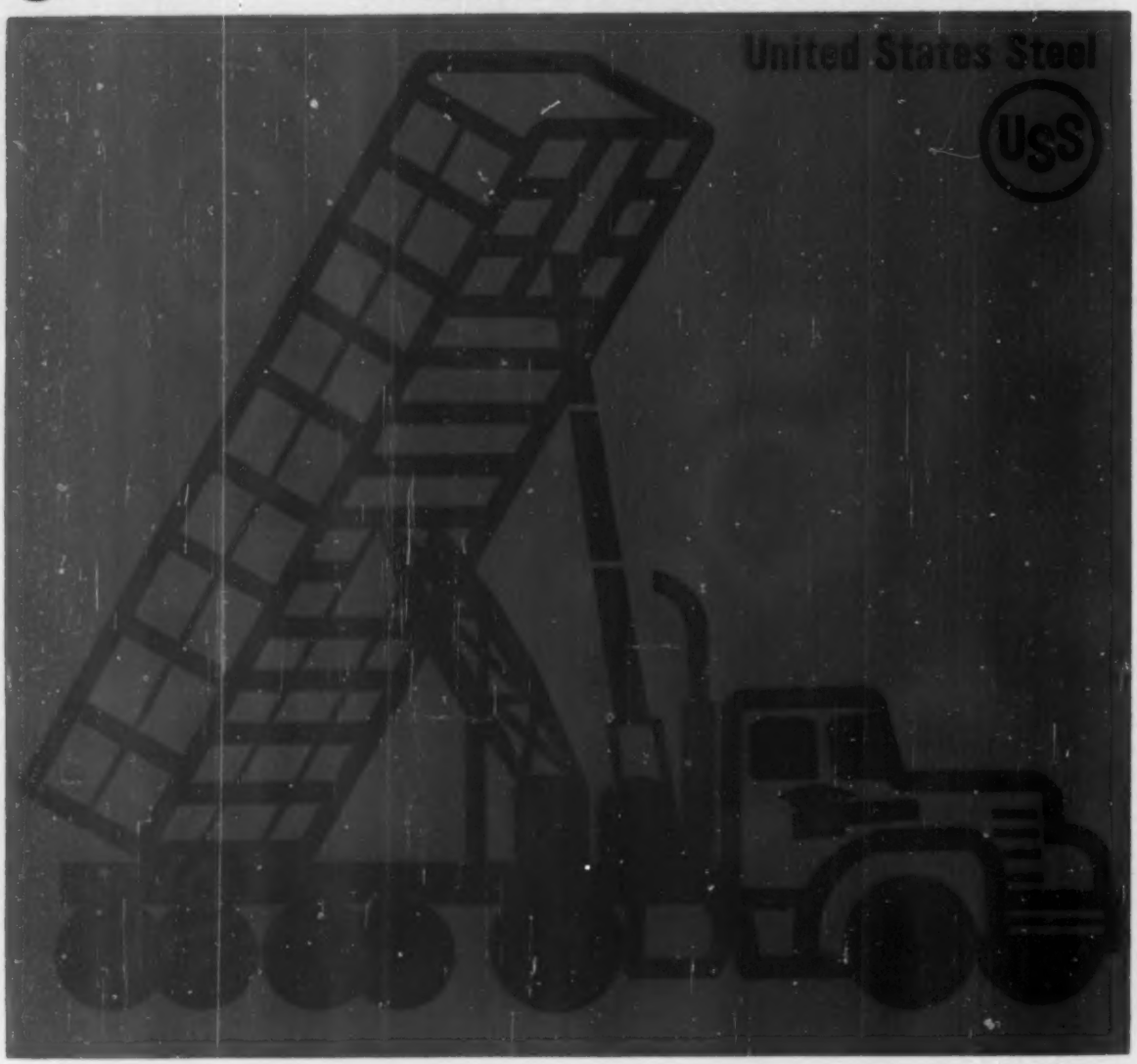
In other words, pound for pound, higher strength steels have yet to be equalled by any other material of construction when you consider strength, endurance and cost.

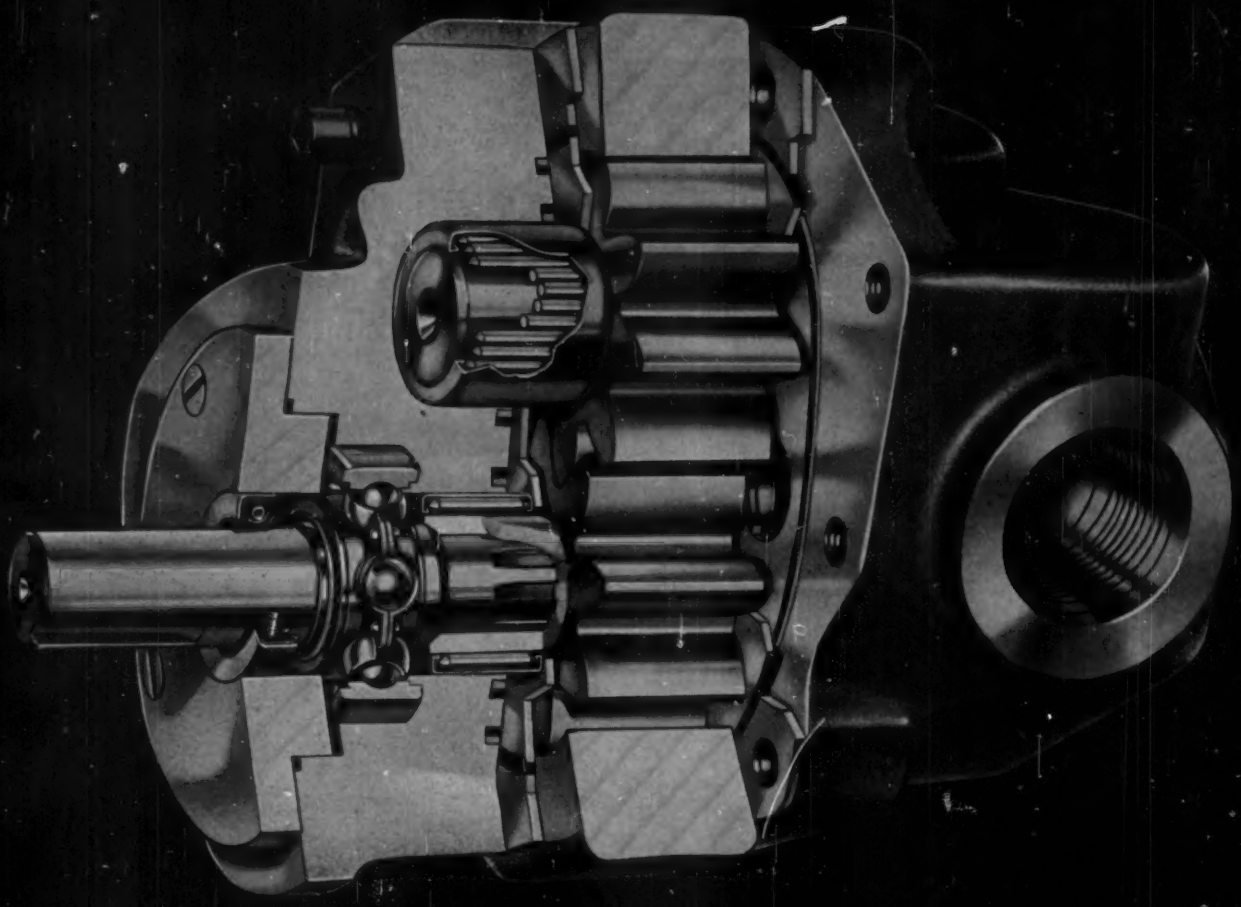
The tremendous success of this model has led to the design of a similar steel trailer that will lop off still another 400 pounds of dead weight (9100 lbs. tare). For more information about USS "T-1" Constructional Alloy or our various grades of high strength steels, write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa. USS, COR-TEN and "T-1" are registered trademarks.

United States Steel Corporation
Columbia-Geneva Steel Division • National Tube Division • Tennessee Coal and Iron Division • United States Steel Supply Division • United States Steel Export Company

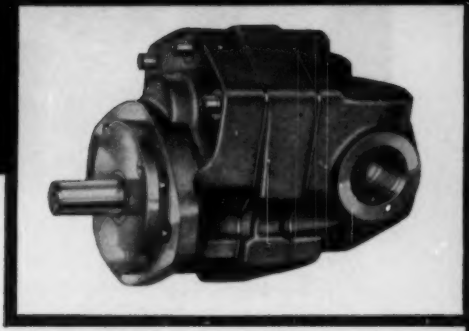
This mark tells you a product is made of modern, dependable Steel.

This new frameless steel trailer built with USS COR-TEN and "T-1" Steels easily withstood a punishing seven-month service test hauling 23,000 tons of hot and cold slag and is ready for several more years of gruelling work. Operator: Hawkins Contracting Company, Pittsburgh, Pennsylvania.





POWER *for the biggest mobile rigs, toughest jobs!*



WEBSTER "JD" SERIES HYDRAULIC PUMP

Match your big equipment to the most rugged duty with this newest Webster and you come up with some interesting answers in hydraulic performance. Fluid power up to 2000 psi! Requires less input horsepower! Saves fuel!

This sectioned view and the specifications at right tell the story. The "JD" Series' anti-friction bearings save power, pressure balanced wear plates assure high volumetric efficiency — other equally important features mean extra work output, trouble-free operation!

Webster Electric "JD" Series Pump is a trim, *very compact* unit designed to fit in tight locations. Ideal for agricultural, construction, industrial, utility equipment — machine tools as well. It's available in 5 sizes from 5 to 17 gpm — attaches easily with a choice of mountings. Ask your Webster Electric representative for all the facts on this powerful new pump — or write direct for engineering detailed sheet HY1-2.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

RACINE · WIS

Circle 257 on Page 19

SPECIFICATIONS

Capacity: 5 sizes, 5 to 17 gpm.

Operating Pressure: Up to 2000 psi.

Operating Speed: Up to 2400 rpm.

Wear Plates: Pressure balanced — prevent clearance changes from heat.

Bearings: 4 anti-friction needle bearings — save power or fuel. Ball bearings on drive shaft to absorb end thrust.

Gears: Smooth-running, spur cut. One piece gear and bearing journal units assure minimum deflection and proper alignment.

Drive: Free-floating internal spline — eliminates key failures.

Seal: Double lip on drive shaft — added protection from seal failure and dirt.

Porting: End, side, or bottom.

Mounting: SAE Type A, 2-bolt mounting flange standard. Foot mounting optional.

now available!

new high temperature alloy data

The complete, up to date story of Carpenter High Temperature Alloys—how they are helping designers and fabricators produce better, more dependable components for the high temperature power plants of today and tomorrow. Includes important technical data on properties and performance of Carpenter VACUMELTROL® (induction vacuum) and CONSUMET® (consumable electrode) alloys with helpful tips on alloy selection and fabrication.

An important addition to your high temperature files—68 pages, attractively bound in loose-leaf covers to accommodate new data as it is issued. Includes technical data on 23 Carpenter High Temperature Alloys, many described for the first time. **Write for your free copy today!** The Carpenter Steel Company, 120 W. Bern St., Reading, Pa.

Carpenter steel

you can make it ***consistently*** better with Carpenter Specialty Steels for specialists

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Export Dept., Port Washington, N. Y.—"CARSTEELCO"
Alloy Tube Division, Union, N. J.
Webb Wire Division, North Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

New Model

FRACTIONAL HORSEPOWER

DYNAMATIC AJUSTO-SPEDE® DRIVE

EATON DYNAMATIC

Steps up Reliability and Durability

New in design but a veteran of proven dependability, the Eaton-Dynamatic Fractional HP Ajusto-Spede Drive offers a compact, low cost solution to adjustable speed control problems. Improvements include:

- **Longer operating life**
- **More uniform cooling**
- **Less noise and vibration**
- **Lighter weight**
- **Compact design**

The Ajusto-Spede Drive offers advantages not found in other methods of control. It is low in cost and easily installed. It is an integral combination of AC constant speed induction motor, eddy-current couplings, and single tube, electronic control. Special control functions, such as acceleration, inching, threading, cascading of multiple units, follower operation, constant tension and clutch motor operation can be provided by remotely mounted electronic controls.

Ajusto-Spede Drives operate on standard 115/230 volt, single phase, 60 cycle or 220/440 volt, 3 phase, 60 cycle alternating current. No special power source is required. Available from the manufacturer or from your nearest Dynamatic Distributor in sizes of ¼, ½, and ¾ HP at 1600 RPM and ½, ¾, and 1 HP at 3200 RPM. Can be supplied with either of two types of electromagnetic friction brakes and integral speed reducer in a wide variety of gear ratios.

Send for Illustrated Descriptive Literature

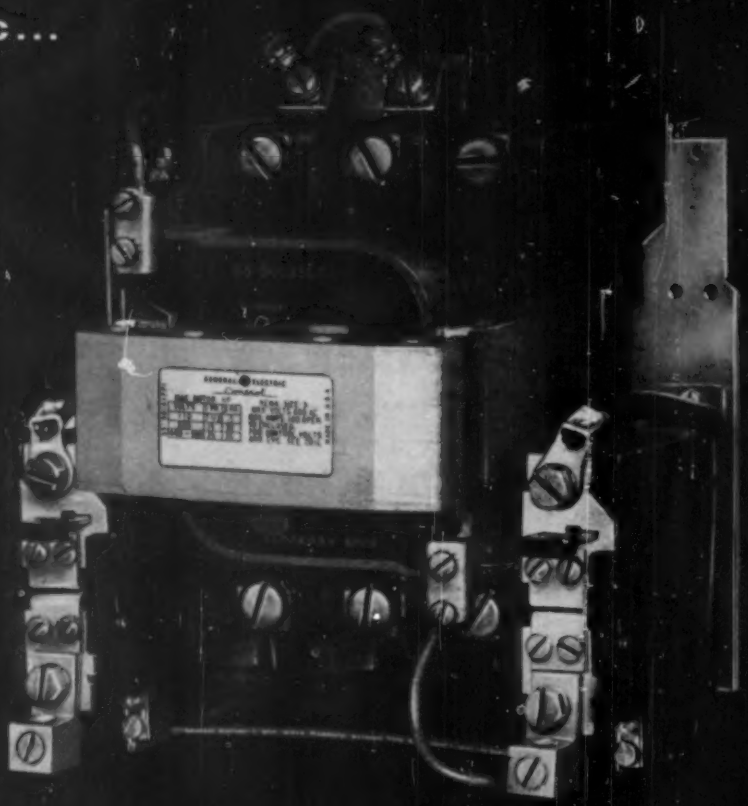
EATON — DYNAMATIC DIVISION —
MANUFACTURING COMPANY
3122 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

...Your partner in progress through research...

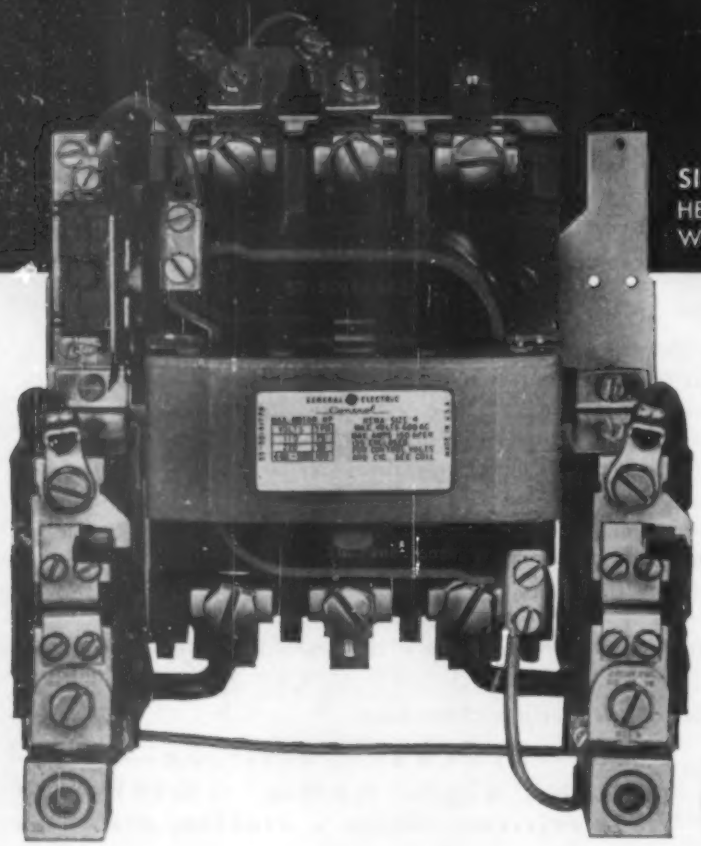
Circle 259 on Page 19

From General Electric...

NEW SMALLER SIZES 3 AND 4 MAGNETIC STARTERS



SIZE 3
HEIGHT—9½ INCHES
WIDTH—8⅜ INCHES



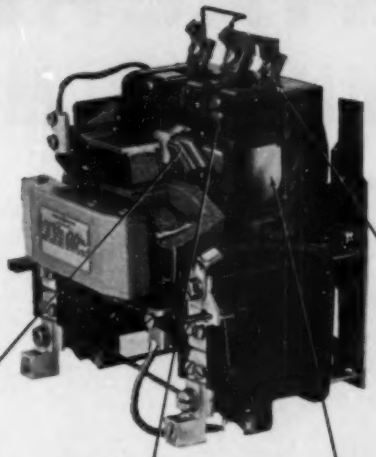
SIZE 4
HEIGHT—10 INCHES
WIDTH—8⅝ INCHES

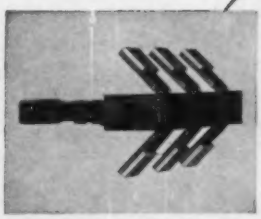
25% HEIGHT

Now General Electric has reduced the height of NEMA Sizes 3 and 4 contactors and starters 25 percent to save you panel material and construction costs. These smaller 100-Line contactors and starters allow you to reduce the size of your control panels. In many cases, you can now mount panels directly on the machines they control instead of building costly floor-mounted panels.

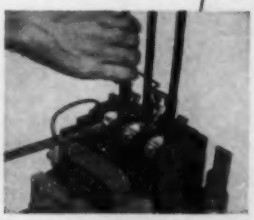
Only 9½ inches high (Size 3) and 10 inches high (Size 4), these starters are about the same height as circuit breakers, disconnects, and other major control components. This means straight wiring runs can be made across the panel with space between troughs determined by other components.

Only General Electric 100-Line Magnetic Starters Give You All These Performance Benefits

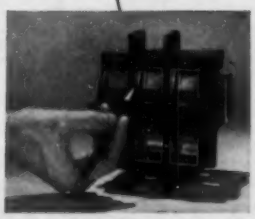




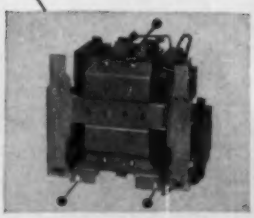
Longer contact life — Unique angled mating of heavy silver-cadmium oxide contacts wipes off contaminants every time starter operates. This reduces arcing and pitting. Shape of 100-Line contacts assures positive "make" with less bounce.



Simplified hook-up — Pressure-type terminals accept 1/0 wire on Size 3 and 250 MCM cable on Size 4. Separate terminal posts contain factory wiring leaving pressure terminals free for your wiring. Terminal posts accept crimp-on connectors.



Improved arc suppression — Magnetic arc trap utilizes circuit breaker method of restricting and quenching arcs. Improved arc cover confines carbon to each separate chamber while exhausting ionized gases that could cause arc restrike.



Easier installation—Starters have three-point keyhole and slot mounting — just hang starter on top screw and tighten. Straight-through wiring on 100-Line starters provides easier terminal identification and connection, shorter wiring runs.

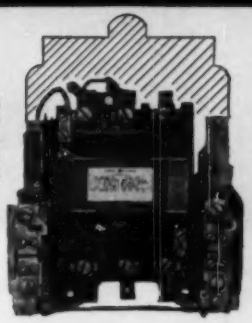
REDUCTION SAVES PANEL SPACE

These new Sizes 3 and 4 starters are also simple to install and wire. The three mounting points are slotted, slip easily over mounting screws, and are readily accessible to power tools. Straight-through wiring, with all line terminals on the top and all load terminals on the bottom, makes hook-up and identification easy, and shortens your wiring runs.

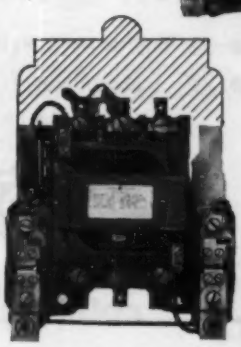
These new starters are part of the 100-Line—a starter design with operational advantages already proved on over *one million* applications.

General Electric 100-Line Sizes 3 and 4 starters are now available, open or enclosed, in all popular forms. Call your G-E sales engineer or distributor, or write for GEA-7326. Section 811-25, General Electric Co., Schenectady 5, N. Y.

You get **MEASURABLE ADVANTAGES**
WITH GENERAL ELECTRIC CONTROL



Save 16 square inches with new Size 3. Cross-hatched area shows outline of previous form.



Save 17 square inches with new Size 4. Cross-hatched area shows outline of previous form.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 260 on Page 19

HITACHI
NO. 2 ML MILLING MACHINES

No. 2 ML Plain Milling Machine

Vibration Damping Device
Due to a vibration damping device of Hitachi's exclusive design contained within the over-arm, minimum vibration will be set up even during higher speeds and feeds operation, so that an excellent finished surface is obtained.

New-Type Arbor Support Bearing
Hitachi's unique super precision-type bearing, a combination of plain metal and needle bearing, is incorporated into the machine to enable high speed cutting with high precision results.

Mono-Lever Control System
Hitachi's unique Mono-lever Control System makes the operation simple and easy. Table-feeding too can be performed with ease.

Backlash Eliminator of Lead Screw
As the use of two independent nuts eliminates backlash on the table feed screw, smooth down-cutting can be effected.

SPECIFICATIONS :

- 53 1/8"×10 1/16" Table
- 28" Longitudinal Traverse
- 16 Table Feeds 1/16" — 78 3/4"/min.
- 16 Spindle Speeds 25 — 1,500 r.p.m.
- 7.5 h.p. Main Motor

Hitachi, Ltd.
Tokyo Japan

Cable Address : "HITACHY" TOKYO

Circle 261 on Page 19

Circle 262 on Page 19→

Grade "A" down the shipping line

Few applications demand so much from a metal as those in the dairy industry. Equipment which comes in contact with milk must be completely corrosion-resistant, easy to keep hygienically clean, and practically indestructible. For years many metals were tested and today, from milk pail to bottle-filler, virtually every piece of equipment used in the handling and processing of milk is made of stainless steel.

Product reliability like this depends on uniformity of both materials and production—the reason J&L stainless is bought regularly by dairy equipment manufacturers. J&L delivers quality consistently, order after order, to help you send Grade A products down the shipping line.

Get consistent quality stainless steel from your J&L distributor, *as* you need it, *when* you need it. He can also provide technical assistance.

Jones & Laughlin Steel Corporation

STAINLESS and STRIP DIVISION · DETROIT 34

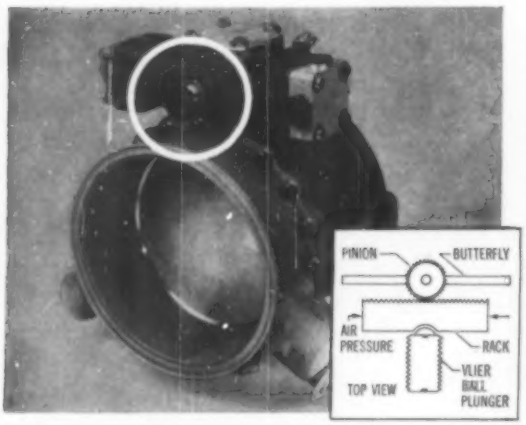
J&L STAINLESS

SHEET · STRIP · BAR · WIRE

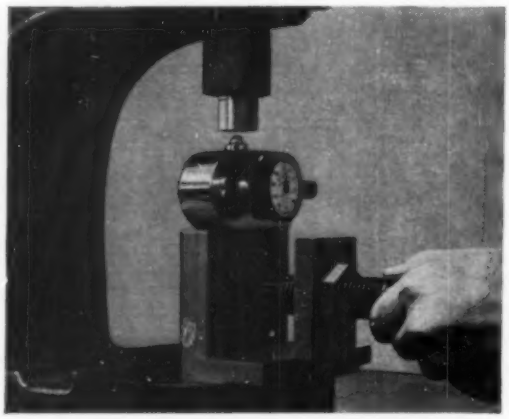
Practical Design Tips

No. 6 of a series

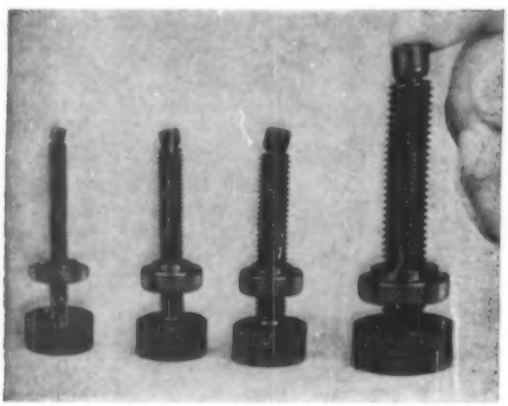
If the profit squeeze is making you look for new ways to reduce costs, look into Vlier products such as those shown below. Hundreds of companies are using these simple, standard parts to replace complicated, specially-machined devices—usually at a fraction of the cost.



SPECIAL VLIER BALL PLUNGER used on this Hermetic Barrier Valve detents on a rack which controls a pinion, which in turn, operates the butterfly. Air pressure forces rack out of detent, opening or closing valve. Plunger, therefore, acts as a positive stop until air pressure is great enough to force shaft past detent. Vlier Ball Plungers are available as standards in sizes from 4-48 x 3/16" to 5/8-11 x 1". Various end pressures. Specials on quantity orders.



SPECIAL VLIER SPRING PLUNGER, shown in test fixture, has laminated phenolic plunger to conform to MIL-P-79B (Type GMG). 1¼" plunger travels .890"; absorbs side load of 105 ±20 pounds. Vlier can provide spring-loaded devices with various diameters, end pressures, plunger lengths, and made of materials to meet your specifications.

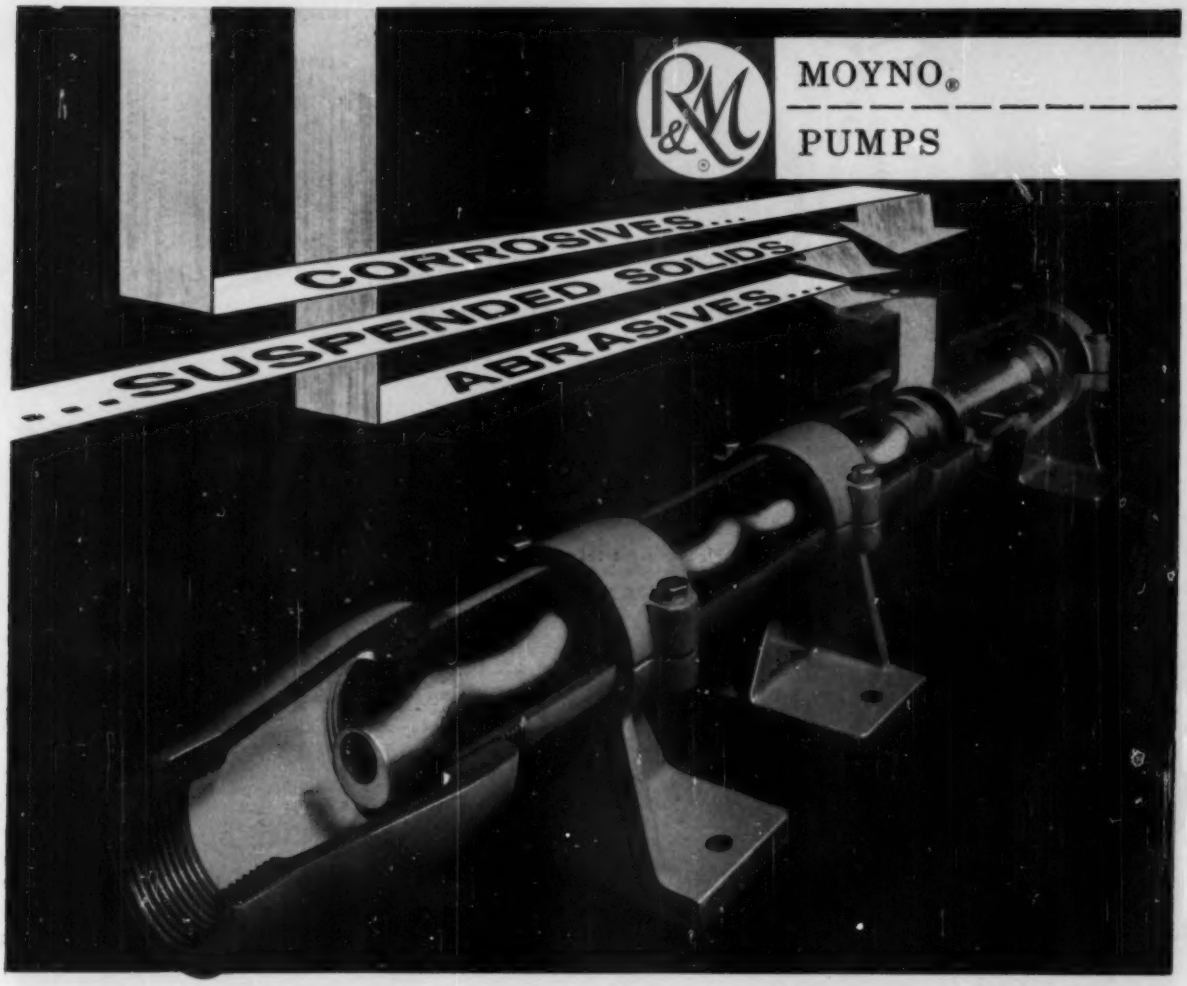


NEW CONTROLLED-TORQUE TOOL incorporates a swivel-pad on the screw end to protect surface of part being held. Pad swivel 7½° in all directions to accommodate off-angles. Has unique ball-joint construction for smooth operation. Named the Vlier Torque Thumb Screw Swivel-Pad Clamp, they are available as standards in ¼-20 x 2¼", 5/16-19 x 2¼", 3/8-16 x 2¼" and ½-13 x 3".

FREE IDEA BOOKLET—16 pages crammed with photographs showing how others have profited by designing standard Vlier parts into their products. Your Vlier distributor will be pleased to give you a copy, or if you prefer, write directly to us.

VLIER
Engineering Corporation
A subsidiary of Barry-Wright Corporation
8900 Santa Monica Blvd., Los Angeles 46, California

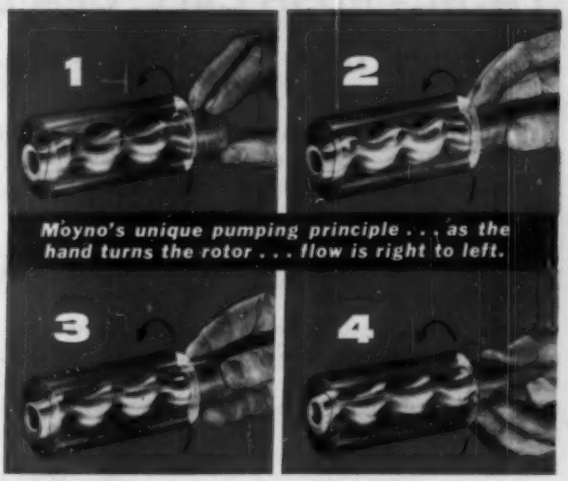
Circle 263 on Page 19



MOYNO® *solves tough pumping problems!*

Moyno's "progressing cavities" successfully handle thin watery slurries, non-pourable abrasives, gnawing corrosives or suspended solids up to 1⅛" dia.—without crushing, foaming or aerating! Material contacts only one moving part, a screw-like rotor revolving in a double-threaded stator. Where corrosives or abrasives are to be handled, rotor and stator are made of special resistant materials that minimize maintenance and prolong pump life. Many materials now pumped by Moyno were once considered "unpumpable" . . . had run up prohibitive maintenance costs on other type pumps or ruined them completely!

Moyno pumps are available in capacities to 500 gpm; pressures to 1000 psi. Learn more . . . write today for new Bulletin 100-MD!



Moyno's unique pumping principle . . . as the hand turns the rotor . . . flow is right to left.

ROBBINS & MYERS, INC., Springfield, Ohio

Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps
Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators
Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.

Circle 264 on Page 19

9 A.M.—RUSH CALL. OEM CUSTOMER OUT OF BEARINGS

In 4 hours, BCA personal service had emergency supply on the way!

The frantic call came from an OEM customer. His normal bearings inventory had vanished under a rush order. Production was screaming for bearings. How fast could we deliver?

In just four hours, a two-day emergency supply of bearings was packed and on its way by air. At the same time, an additional five-day supply was being loaded for truck shipment to the customer.

Personal service like this is not unusual at BCA, though we much prefer orders placed in the normal fashion. Because we're flexible in operation, we're able to eliminate red tape and wasted time. This is good for us, and even better for our customers. And this is true not only for delivery, but for engineering and production operations, too.

In addition, BCA offers complete research and engineering facilities and equipment, including specially designed machines for testing bearings, often under conditions identical to customers' actual operating conditions.

We make ball bearings for OEM and replacement use, in a complete range of types and sizes, for almost every industry . . . automotive, machine tool, construction, agriculture, and others. For complete information or technical assistance on bearings problems, contact Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

BCA

BEARINGS COMPANY OF AMERICA

ball bearings

DIVISION OF FEDERAL-MOGUL-BOWER BEARINGS, INC.

Circle 265 on Page 19

ARE YOU ACQUAINTED WITH THE NEWEST ADDITION TO UNION CARBIDE'S FAMILY OF PLASTICS

BAKELITE®
POLYPROPYLENE

High heat resistance
●
No stress cracking
●
Lowest specific gravity
●
Outstanding flex life
●
Easy processability
●
Good mechanical, electrical and chemical properties
●
Economical
●
Low MVT and low gas permeability

Investigate BAKELITE® Polypropylene for MOLDING AND EXTRUSION

(All formulations except food grades are heat stabilized for prolonged use at elevated temperatures)

GENERAL PURPOSE: for molding and extrusion.

HIGH IMPACT: 3 to 5 times tougher than general-purpose materials.

FOOD APPLICATIONS: FDA-sanctioned

HIGH FLOW: for deep-draw moldings

U-V STABILIZED: for outdoor applications

BLOW MOLDING: short flow for parison stability

THERMOFORMING: non-sagging

We would be glad to discuss polypropylene or any of our other plastics materials with you. These include high, medium, and low density polyethylene, polyethylene copolymers, phenolics, styrene, epoxy and vinyl resins and compounds. Simply fill out the adjacent coupon.

UNION CARBIDE PLASTICS

BAKELITE and UNION CARBIDE are registered trade marks of Union Carbide Corporation.

Union Carbide Plastics Company
Division of Union Carbide Corporation
Dept. KQ-84J, 270 Park Avenue, New York 17, N.Y.

I am interested in the possibilities of using polypropylene for _____

NAME _____

FIRM _____

ADDRESS _____

CITY _____ ZONE ____ STATE _____

Circle 266 on Page 19

Replace old-fashioned couplings with Rockwell-Standard's

BLOOD BROTHERS

HEAVY-DUTY INDUSTRIAL DRIVE LINES

ROCKWELL-STANDARD ENGINEERS specifically designed Blood Brothers Heavy-Duty Industrial Drive Lines to replace couplings in industrial applications. They improve machine performance and efficiency...last longer... give better service than any coupling. They often reduce costs by eliminating the need for bearings and supports required by conventional coupling installations. Wearing parts are quickly replaced and even drive lines can be replaced in 15 minutes!

Available in capacities up to 500,000 torque inch pounds, they are adaptable to a variety of applications—rolling mills, oil field equipment, irrigation pumps, cargo carriers, marine drives, logging winches, mining machinery and many others.

Blood Brothers Industrial Drive Lines offer these special features:

• Wing bushings that eliminate costly flange yokes and reduce down time during servicing. Simply remove 8 bolts for complete disassembly • Sliding spline provides for quick, easy assembly—variations in mounting locations—longitudinal shaft movements during operation—deflections and temperature changes • Easy access to lubrication fittings.

Another Product of...

ROCKWELL-STANDARD CORPORATION

Universal Joint Division, Allegan, Michigan

this power plant packs a Sunday Punch ...EVERY DAY IN THE YEAR!

This husky self-contained power unit combines true economy with tremendous efficiency to power cylinders, chucks, clamping devices and many other hydraulic machines.

Teamed up with Logan's "Super-matic" cylinder, this unit can generate thousands of pounds of pressure and maintain a steady, trouble-free operation month after month—at top production speeds. If you would like additional information about this compact power unit, or any of Logan's other products, just fill in and mail the coupon below.

LOGAN
AIR AND HYDRAULIC OPERATED MACHINES

Check the items you want, fill in your name and address, tear out and mail to:

Logansport Machine Co., Inc. • 710 Center Avenue, Logansport, Indiana

Circle 268 on Page 19

__100-1 AIR CYLINDERS
__100-2 MILL-TYPE AIR CYLS.
__100-3 AIR-DRAULIC CYLS.
__100-4 AIR VALVES
__100-5 LOGANSQUARE CYLS.
__100-6 ULTRAMATION CYLS.
__100-7 SUB-PLATE AIR VALVE
__300-1 CHUCKS
__300-2 PRESSES
__200-1 HYD. POWER UNITS
__200-2 ROTOCAST HYD. CYLS.
__200-3 750 SERIES HYD. CYLS.
__200-4 and 200-7 HYD. VALVES
__200-6 SUPER-MATIC CYLS.
__ABC BOOKLET
__CIRCUIT RIDER
__CALCULATOR
__FACTS OF LIFE

Please send copy of catalog

NAME.....

TITLE.....

COMPANY.....

ADDRESS.....

MAY WE ADD YOUR FASTENER "SPECIAL" TO OUR 12,000

This STEELMARK of the American Steel Industry tells you a product is made of Steel. Look for it when you buy.

Steel

OR FORMED PART PIECE SHOWCASE

Pictured here are a few of the more than 12,000 different fastener and formed part "specials" we've produced for hundreds of satisfied customers. Result: our Special Products Team has the problem-solving know-how to tackle any product requirement that a standard fastener or formed part can't handle.

We'd like to put this experience to work for you—add your "special" to our showcase of precision parts—and prove that we can save you money in the process.

Republic does the job the way that's best for you. We'll completely design, engineer and produce your special—make it from your blueprints, to your specifications—or, produce blanks that are ready for your finish machining.

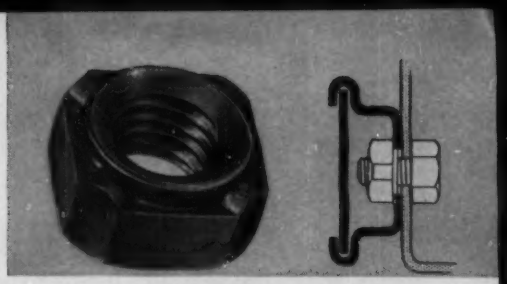
Newest methods and facilities keep costs down. Cold forming, hot forming, extruding, upsetting (and combinations of these methods) are used to best advantage. Complete machining, heat treating, and surface finishing equipment are also available. Savings realized from this single-source operation mean lower costs to you.

For complete information on Republic's unique capabilities for producing your Fastener and Formed Parts "Specials" send the attached coupon today.

Circle 271 on Page 19

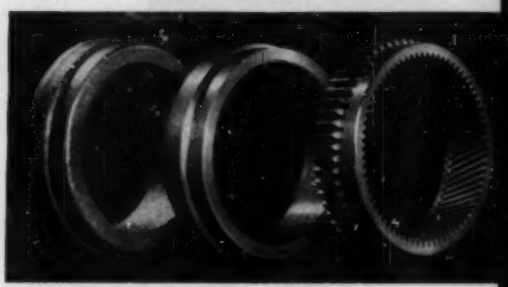
REPUBLIC STEEL

REPUBLIC HAS THE FEEL FOR MODERN STEEL



BLIND FASTENING APPLICATIONS are no problem with Republic Midland Weld Nuts—newest addition to the more than 20,000 different types and sizes of Republic Fasteners. They save time, cut costs. Simply premount in places where a wrench can't reach, spot weld in seconds with standard projection welding equipment. Circular pilot guides Republic Midland Weld Nuts into position, protects threads, simplifies automatic feeding. Send for data.

Circle 272 on Page 19



ABILITY TO WITHSTAND SEVERE SHOCK, strain, impact, and wear were important factors in the selection of Republic Hot Rolled Alloy Steel for planetary ring gears—product of Warner Gear Division, Borg-Warner Corporation, Muncie, Indiana.

Records prove that the uniformity of this alloy steel has reduced reject rate and scrap loss. This, along with exceptionally high machinability, is holding unit cost of the planetary ring gear to an absolute minimum. Send for data on Republic Hot Rolled Alloy Steel.

Circle 273 on Page 19

EASY TO FABRICATE, bend, flange, weld, Republic ELECTRUNITE® Stainless Steel Tubing is ideal for a variety of design and engineering requirements. Republic combines leadership in the production of welded tubing, and in stainless and alloy steels to give you close-tolerance I.D. and O.D. concentricity, uniform metallurgical and mechanical qualities. Call your Republic Representative for fast service—price and delivery quotations to you within 24 hours. Mail coupon for more information.

Circle 274 on Page 19

REPUBLIC STEEL CORPORATION
DEPT. MD-2190-A
1441 REPUBLIC BUILDING
CLEVELAND 1, OHIO

Please send more information on:

- ☐ Fastener and Formed Parts "Specials"
- ☐ Alloy Steel
- ☐ ELECTRUNITE Stainless Steel Tubing
- ☐ Republic Midland Weld Nut

Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

NO STARTING PROBLEMS

with

WAGNER CAPACITOR-START MOTORS

Quick Break Switch

The starting winding is disconnected from the line by this Wagner designed switch . . . test proved to make more than a million breaks. (That adds up to two starts per hour for 50 years!)

Quick Connect Terminals

Brass tabs on terminal studs permit quick, easy connection of leads . . . cut wiring time to speed assembly line production. Simply press the lead receptacle on to the stud—a positive connection is assured.

Pack more power into less space . . . give long troublefree service . . . are easy to hook up

Here are general purpose single-phase motors that have high starting torque and high pull-in torque. When used in the proper application and supplied with voltage close to their rating, they'll give positive starts every time. Troublefree operation is assured . . . thanks to the positive action of the Wagner governor mechanism and long life quick-break switch.

Wagner Type RK Motors pack more power into less space. Small enough to fit in tight spots, their ruggedness is built-in . . . permits direct mounting. They are available in a range from ¼ through 5 horsepower, with sleeve or ball bearings, and with rigid bases or resilient mountings. And, sleeve bearing fhp models can be operated in any position.

Get these motors from leading distributors in your city, or from Wagner Sales Offices in 32 cities across the country. Your Wagner Sales Engineer will be glad to help you select the right motor for your application. Wagner Bulletin MU-217 gives full details on Capacitor-Start Motors.

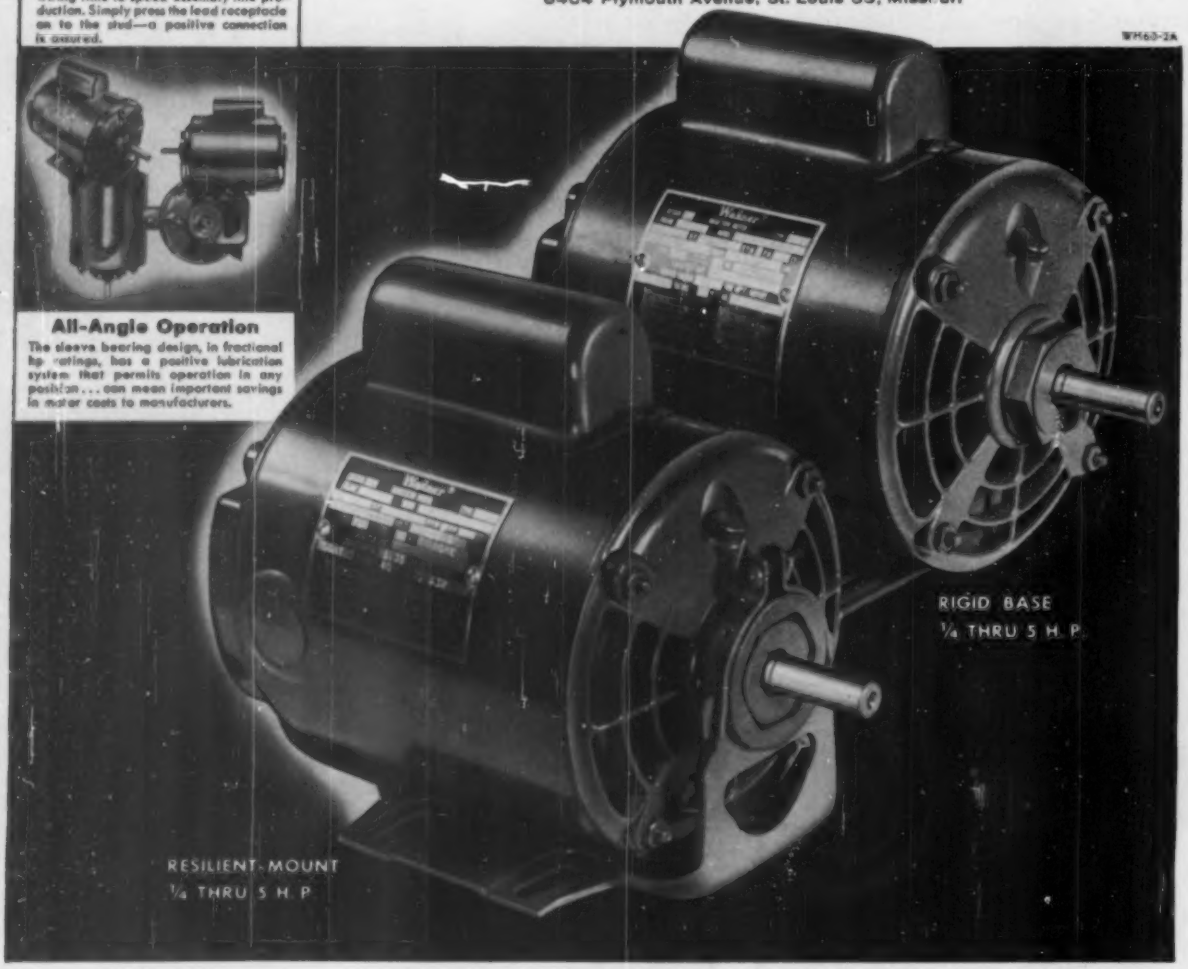
Wagner Electric Corporation

6404 Plymouth Avenue, St. Louis 33, Missouri

WM60-2A

All-Angle Operation

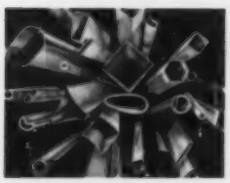
The sleeve bearing design, in fractional hp ratings, has a positive lubrication system that permits operation in any position . . . can mean important savings in motor costs to manufacturers.



RSVP SUPERIOR

SHAPED TUBING

to fit any design requirement



Formed to extremely close tolerances to satisfy specific design requirements. Telescoping sizes also available. End uses include Bourdon springs, surgical instruments, batons, aircraft structural parts, gun drill shanks, radar screens, door latches, electrical equipment, antennas, golf club shafts, fishing rods, and bushings. Superior regularly produces shaped tubing in many analyses of stainless steel, carbon and alloy steels, nickel and nickel alloys, and glass sealing alloys.

RETURN THIS CARD FOR COMPLETE DATA

SUPERIOR TUBE COMPANY
Norristown, Pa.

Send me complete information on the following tubing:

- ☐ Shaped Tubing
- ☐ Needle Tubing
- ☐ Other_____

Name_____ Title_____

Company_____

Street_____

City, Zone, State_____

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

West Coast: Pacific Tube Company, Los Angeles, California

FIRST CLASS
Permit No. 9
Collegeville, Pa.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

POSTAGE WILL BE PAID BY—
SUPERIOR TUBE COMPANY
Collegeville, Pa.

RSVP SUPERIOR

MECHANICAL NEEDLE TUBING

strong, flexible, corrosion resistant

Excellent mechanical properties up to 650°F. Made in Type 304 stainless steel in gages 6 through 33 in 28 standard sizes. Lengths to 12 ft. max. Close quality-control assures bright, clean surfaces. Widely used in the metalworking industries, particularly in the industrial instrument field, for a host of mechanical applications. Available annealed as well as in the hard-drawn temper.

RETURN THIS CARD FOR COMPLETE DATA

Superior Tube

The big name in small tubing
NORRISTOWN, PA.
West Coast: Pacific Tube Company, Los Angeles, California

Which of these parts should be investment cast?

. . . *All* the parts except the milling machine collet at the top right—which is a "natural" for conventional lathe work. Even the helical impeller the men are examining is best made as an investment casting—the helix is undercut in such a way that no cutting tool could reach inside to remove the metal.

"Naturals" for investment casting are usually parts that are too intricate to be made economically by any other process, or involve alloys or quantities that make them impractical to produce by other methods. In other words, when it looks as if you might have to sacrifice a design because its complexity makes the cost prohibitive, or forego a preferred alloy because it is difficult to machine, then it's time to take a long, hard look at investment casting.

But . . . it's not always as easy as it sounds to spot the parts that are "made" for investment casting. That's where the Arwood sales engineer comes in. He knows Arwood expects him to show a customer how to get the most from the process. To help keep your cost down he may have to suggest a filleted radius here . . . or a tolerance opened up there. Then too, on occasion he may readily have to admit the part should not be investment cast at all. However, he also knows that if you just can't have the part made any other way, Arwood will go all the way down the line to have it investment cast for you.

Our five plants cast every castable metal and alloy, including magnesium and superalloys. Each has its own research, tooling, quality control and production facilities. In short, if it can be investment cast, we can investment cast it.

LIKE TO LEARN MORE ABOUT INVESTMENT CASTING?

Write us for a complimentary copy of our 44-page manual, "Practical Guide to Investment Casting." Among other sections it includes practical tips on designing for investment casting, as well as analyses and physical and mechanical properties of all the metals and alloys cast by Arwood.

Machine the simple . . . cast the complex

A complete service from design through tooling, production and finish machining. Seventy-one engineering representatives from coast to coast.

arwood

ARWOOD CORPORATION • **315 West 44th Street, New York 36, New York**

PLANTS IN BROOKLYN, N. Y.; TILTON, N. H.; GROTON, CONN.; LOS ANGELES AND LA VERNE, CALIF.

WHY PAY FOR METAL WASTE?

Here is how to cut costs on your next tube order... by eliminating excessive metal waste and unnecessary machining time.

NOW FOR THE FIRST TIME you can order the exact size tube O.D.'s you need from 2.25" to 50" with wall thicknesses from .25" to 8". An exclusive "first" in centrifugally spun tubing—the ACIPCO CERAM-SPUN® process* makes this revolutionary development possible.

YOU BUY WHAT YOU NEED... NO MORE. Furthermore, the cost of unwanted crop ends can be eliminated and tubes can be cast to specified lengths from 4 feet to 20 feet. Longer lengths are made by welding.

OTHER ADVANTAGES? ACIPCO's complete "under one roof" operations — including heat treating, machining and welding — save you the delays and excessive costs that often result in buying from multiple supply sources.

Let us tell you more about ACIPCO CERAM-SPUN® ...contact us today. ACIPCO STEEL PRODUCTS, Division of American Cast Iron Pipe Company, Birmingham 2, Alabama.

*Patent applied for

ACIPCO CERAM-SPUN®
STEEL TUBING

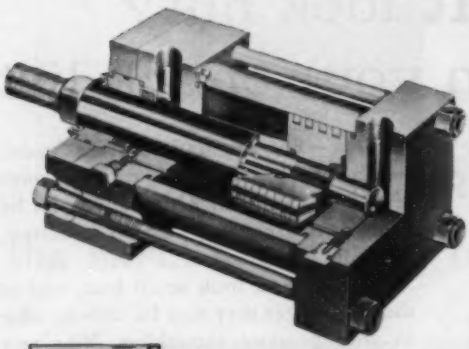
Circle 277 on Page 19

Denison and Denison HydrOILics are registered trademarks of Denison Eng. Div., ABSCO

DENISON HydrOILics

Now...from **DENISON**...
complete new line of
rugged, compact hydraulic...

CYLINDERS



NEW DENISON HYDRAULIC CYLINDER LINE *includes units for pressures from 1000 to 5000 psi, bore sizes from 1⅛" to 14", 17 different mountings. Write for free literature.*

HYDRAULIC CYLINDERS—combining the same high standards of quality as well-known Denison hydraulic pumps, motors, valves, controls—are now available in a complete line of standard sizes for a wide range of applications. Denison hydraulic cylinders are carefully designed for rugged service, long life and easy maintenance with these outstanding features for reliability and economical performance—

Tapered cushion piston provides gradual, shock-free deceleration. No need for cushion adjusting screws.

Chrome plated, high tensile steel piston rod has hard, smooth surface and high corrosion resistance.

Teflon rod wiper keeps rod clean and free of abrasive dirt and dust.

Multi-lip rod packing assures low friction and long life. Self-adjusting to pressure and wear.

Fine grain alloy cast iron piston is precision fit, threaded and pinned to rod.

Cartridge type bronze bushing for maximum wear resistance. Simple to change with only a wrench.

Micro-finished steel cylinder tube with extrusion-proof seals at both ends.

Contact your nearby Denison hydraulic field specialist for full details.

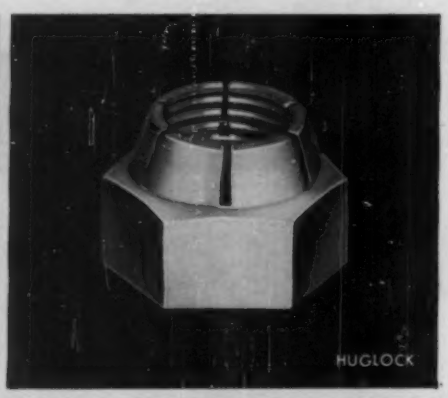
DENISON ENGINEERING DIVISION
American Brake Shoe Company
1240 Dublin Road • Columbus 16, Ohio

HYDRAULIC PRESSES
PUMPS • MOTORS • CONTROLS

DENISON
HYDRAULIC POWER

Circle 278 on Page 19

NAT'S quick facts about Fasteners...



Looking for the **right** lock nut? Put these four high on your check list

By taking an early look at these National all-metal lock nuts, you may often be able to make quick work of finding the locking member that best meets the requirement of your particular job.

Once over lightly, here are the advantages they offer you.

MARSDEN—For minimum cost and average conditions. Free-running until seated. One-piece, fully re-usable.

HUGLOCK—For use under adverse conditions. Locks without seating. One-piece design, and fully re-usable.

CONELOK—For applications requiring high-fatigue life, as assured by closed stress paths in Conelok's locking sections. Locks without seating. One-piece design, and fully re-usable.

DRAKE—For use under severe stress, shock or vibration. Free-running until seated, or can be locked at any point by using two wrenches. Two-piece design, and fully re-usable.

Take a good look at all four, and at the advantages they may be able to offer in your product assemblies. You may not be thinking of an application right now, but get the literature* and keep it handy in your files, just in case.

*There's a folder on the Conelok, and a booklet on the others. Write for your copies.

National PRODUCTS

The National Screw & Mfg. Company · Cleveland 4, Ohio

California Division, The National Screw & Mfg. Company • 3423 South Garfield Avenue, Los Angeles 22, California

Circle 279 on Page 19

NEW from Rohm & Haas!

IMPLEX R

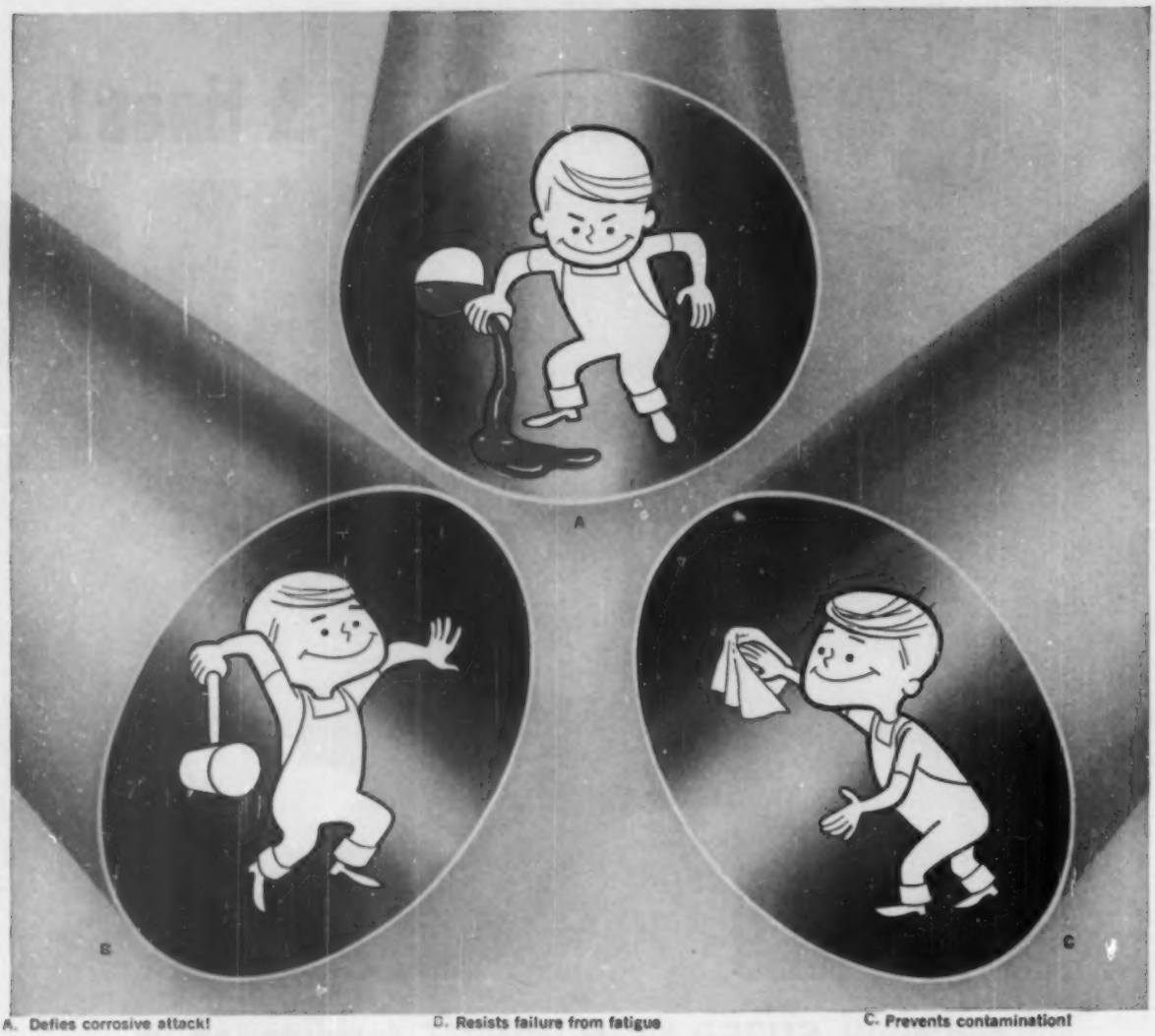
the NEW, SUPER HIGH IMPACT, formulation in the IMPLEX® family of tough, rigid acrylic molding powders

- **MAXIMUM IMPACT STRENGTH**—*Double* the highest impact strength previously available in IMPLEX acrylic molding powders.
- **LIGHT TRANSMITTANCE**—High degree of transparency in natural color, resulting in *increased range of colors . . . more color brilliance . . . more color depth.*
- **GOOD MOLDABILITY**
- **EXCELLENT STABILITY**—Dimensionally stable—no plasticizer . . . low water absorption . . . resistant to chemicals and staining . . . free of odor or taste.
- **HIGH SURFACE GLOSS**—Lustrous, smooth surfaces in a complete range of rich, deep colors.

Write today for color samples, technical data and table of physical properties on IMPLEX R—for SUPER HIGH IMPACT in quality molded parts.

ROHM & HAAS

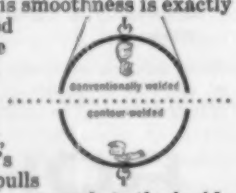
PHILADELPHIA 5, PA.



A. Defies corrosive attack! B. Resists failure from fatigue C. Prevents contamination!

The "Gravity Kid" shows how
ONLY CONTOUR-WELDING COMBINES ALL THREE BENEFITS IN A SINGLE TUBE

Feel the inside surface of a Contour-welded* stainless tube. It's so smooth you barely feel the weld. Even with a microscope you see fewer crevices and flaws than you find in other makes of tubing. This smoothness is exactly the reason why Contour-welded tubing is so resistant to corrosive attack...to product incrustation ...and to failure from fatigue.



Contour-welded tubing is smoother than other tubing, welded or seamless, because it's welded at the bottom. Gravity pulls the metal down so that the weld corresponds to the inside contour of the tube. There's no bulge on the inside surface. Even on the outside surface, the seam closely conforms to the tubing shape.

Just the opposite occurs in conventionally-welded tubings. There, gravity pulls the molten metal down into the tube. This can form a bead that is difficult to remove by cold working. And cold working can lead to undercuts that become focal points for corrosive attack, incrustation, and even failure from fatigue.

Contour-welded tubing is smoother than seamless. That's because it's formed from uniformly rolled strip steel, whereas seamless must be produced by extruding or piercing.

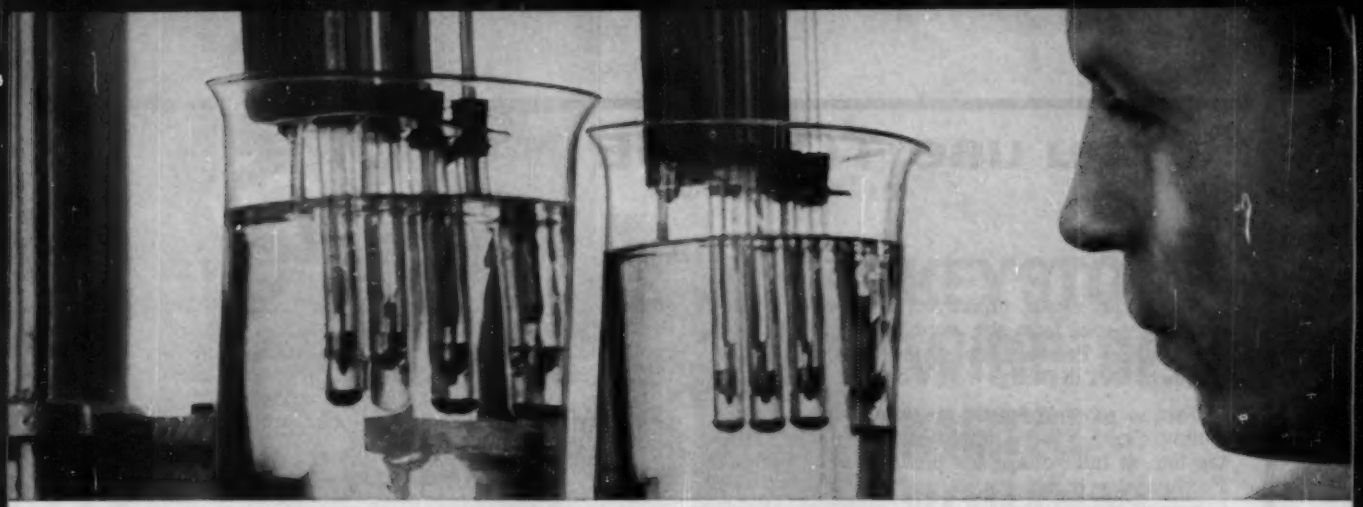
But get the full story. Write today for our free 48-page manual, which describes tubing sizes from 1/8" to 40" O.D., in stainless and high alloy steels, titanium, zirconium, zircalloy, and Hastelloy**.

*Trent's patented process — U.S. Patent 2,716,692

**Trademark Haynes Stellite Co.

TRENTWELD® Stainless and High Alloy Tubing

Trent Tube Company, a Subsidiary of Crucible Steel Company of America, General Offices and Mills: East Troy, Wisc.; Fullerton, Calif.



Dropping point test shows how greases react to heat. Beaker fluid has been heated to 390°F. All greases tested except Darina (second tube from left) have passed from solid to liquid state.

BULLETIN:

Shell reveals the remarkable new component in Darina Grease that helps it save up to 35% on grease and labor costs

Darina® Grease is made with Microgel*, the new thickening agent developed by Shell Research.

Darina lubricates effectively at temperatures 100° hotter than most conventional soap base greases can withstand.

Read how this new multi-purpose industrial grease can help solve your lubricating problems and even save you up to 35% on grease and labor costs.

THERE IS no soap in Darina Grease. No soap to melt away—wash away—or dissolve away.

Instead of soap, Darina uses Microgel—a grease component developed by Shell Research.

What Microgel does

Because of Microgel, Darina has no melting point. It won't run out of gears or bearings.

Compared with most conventional soap-base greases, Darina provides significantly greater protection under adverse service conditions.

Mix water into Darina and the grease does not soften. It shrugs off water—won't emulsify.

Resists heat

Darina will withstand operating temperatures 100° hotter than most conventional multi-purpose greases. It cuts leakage and reduces the need for special high-temperature greases.

Also, Darina resists slumping, thus forming a more effective seal against foreign matter.

Saves money

Shell Darina can reduce maintenance expenses while it protects your machinery. Savings of up to 35% on grease and labor are quite possible.

In some cases lubrication intervals have been extended to double what they were before. Less grease is consumed and less time consumed applying it.

For details, see your Shell Representative. Or write: Shell Oil Company, 50 West 50th Street, New York 20, New York.

*Registered Trademark

SHELL

A BULLETIN FROM SHELL
—where 1,997 scientists are helping to provide better products for industry

Circle 282 on Page 19

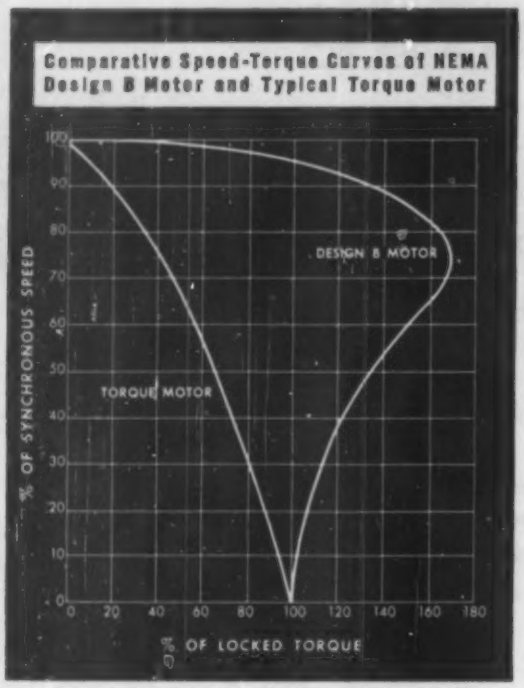
if you use TORQUE MOTORS

... the name is *Peerless*

The torque motor, unlike any other electric motor, is a special from the word go. That situation alone makes Peerless one of the best sources for torque motors in ratings from 2 oz. in. to 200 lb. ft.

Torque motors deliver maximum rated torque without damage to the windings when stalled across the line at full voltage for predetermined periods. Peerless also builds torque motors which provide a nearly constant torque while operating at less than synchronous speeds.

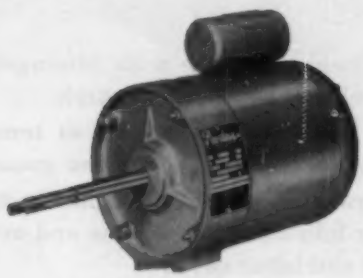
All standard frame sizes; all types of mountings; high torques; special paint and varnish treatments; and Class A, B and H insulation are available from Peerless. Torque motors require unusually close cooperation between the motor supplier and the customer's engineers. This cooperation is a Peerless specialty. We will work with you to produce the one torque motor that powers your product best.



The speed-torque curve varies from that of a conventional motor. The torque motor curve is almost linear. Maximum torque occurs at the stalled position. For this reason, torque motors are used most often where a holding or resisting force is required.

Weather-Tight Special Flange

Explosion-Proof Torque Motor with Brake



Special Flange Reversing Hoist Motor Single Phase

NEW TORQUE BULLETIN-This bulletin outlines basic facts about Peerless torque motors and shows applications. It is available FREE. Write for it today.

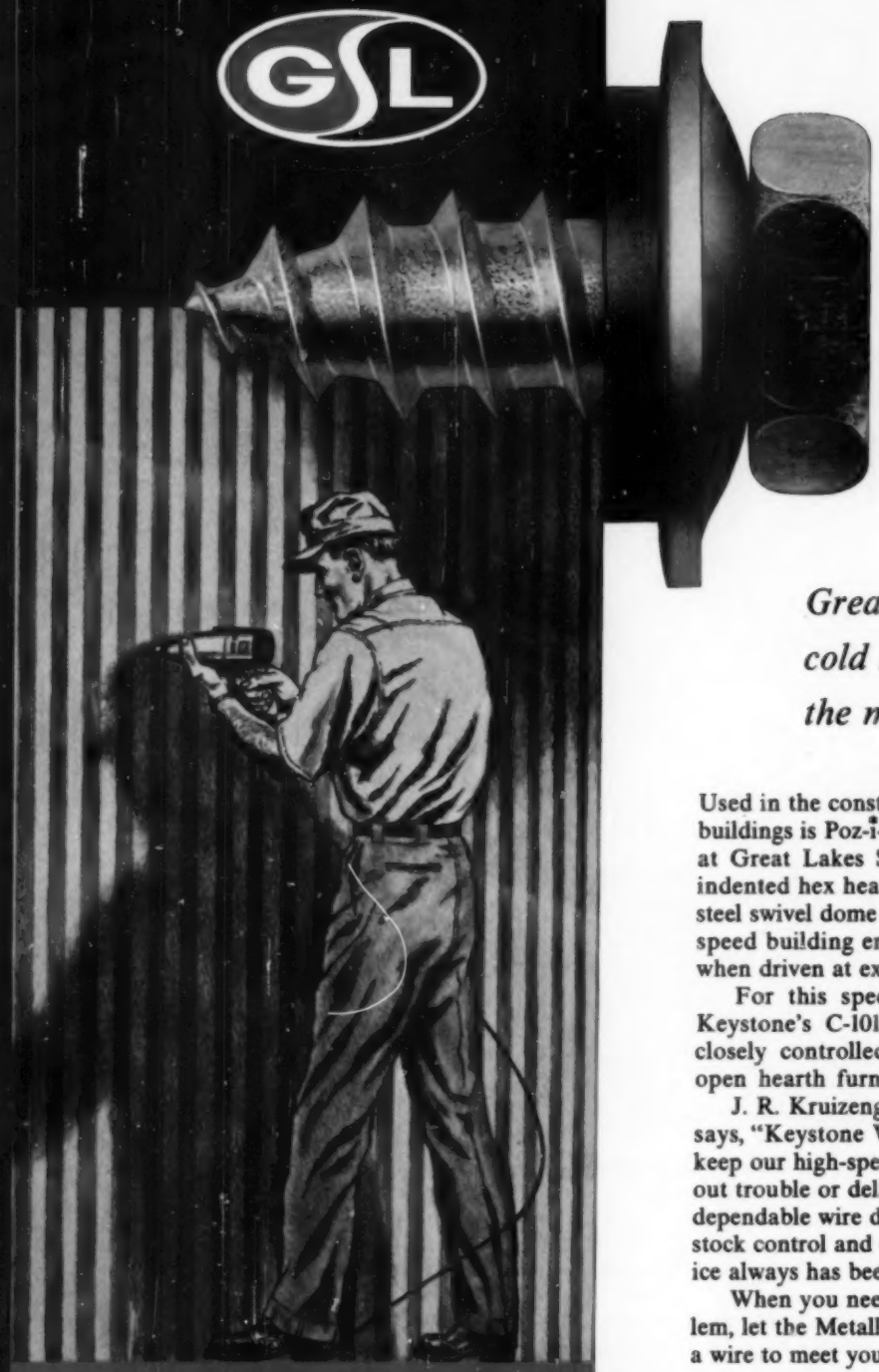
Peerless Electric Division, H. K. Porter Company, Inc., Warren, Ohio

PEERLESS ELECTRIC DIVISION PORTER **H.K. PORTER COMPANY, INC.**

PORTER SERVES INDUSTRY with steel, rubber and friction products, asbestos textiles, high voltage electrical equipment, electrical wire and cable, wiring systems, motors, fans, blowers, specialty alloys, paints, refractories, tools, forgings and pipe fittings, roll formings and stampings, wire rope and strand.

Circle 283 on Page 19

Circle 284 on Page 19→



KEYSTONE WIRE SPEEDS METAL BUILDING ERECTION

Great Lakes Screw Corp. cold heads **Poz-i-seal**®, *the moisture sealing fastener*

Used in the construction of industrial fabricated metal buildings is Poz-i-seal, a sheet metal fastener developed at Great Lakes Screw Corp., Chicago, Ill. It has an indented hex head with Type A point and a hardened steel swivel dome washer, plus rubber seal. Designed to speed building erection, it provides positive seal even when driven at extreme angles.

For this special fastener Great Lakes specifies Keystone's C-1018 Direct Drawn Wire made under closely controlled manufacturing procedures — from open hearth furnace to finished wire.

J. R. Kruizenga, Vice President in Charge of Sales, says, "Keystone Wire flowability and uniform quality keep our high-speed heading machines operating without trouble or delay. Keystone Steel & Wire Company dependable wire deliveries help us maintain an efficient stock control and continuous operation. Keystone service always has been excellent."

When you need a solution to a wire forming problem, let the Metallurgists at Keystone help you develop a wire to meet your most exacting specifications.

Keystone Steel & Wire Company, Peoria, Illinois

KEYSTONE

WIRE FOR INDUSTRY
MADE AT PEORIA, ILLINOIS, U.S.A.

Tooling Savings: 60%—Production Savings: 25%

"are you getting your metal's worth?"

If time and money were no object, you could assemble this refrigerator door hinge from a steel stamping, a brass stamping, screw machine parts and just one die casting. Then you could keep busy with some tricky operations necessary to attach the hinge halves—drilling blind holes accessible only with an angle drive drilling head and staking steel pins in the holes.

However, Die Cast Products, Inc. of Gardena, California prefers the 60% reduction in tooling costs and the 25% drop in production costs achieved by a unique design using four zinc die cast components which are cast in one shot and trimmed in one operation. That way they are faced with no other secondary operations before plating—and assembly is simple.

To find out how to put zinc die castings to work for you, see your nearest die caster for information about their properties, use, design techniques and machining practices. REMEMBER—ZAMAK GIVES YOU MORE FOR LESS. ARE YOU GETTING YOUR METAL'S WORTH?

NJZ

HORSE HEAD PRODUCTS

THE NEW JERSEY ZINC CO.

160 FRONT STREET · NEW YORK 38, N.Y.

Circle 285 on Page 19

MACHINE DESIGN
October 26, 1961

Measure of Success

WHEN his prospective employer asked if he had graduated in the upper half of his class, Joe had to admit that he had not. But he added brightly that he had been one of those who made it possible for there to be an upper half.

A few weeks ago, on this page, we used some recent statistics on engineers' salaries to point up the fact that our profession does offer satisfactory monetary rewards to those willing to go after them. Our figures, of course, applied to the upper half, upper quarter, and upper tenth.

It is natural for those in that half of the engineering population earning less than the national median to feel that they have somehow missed the boat. One reader goes so far as to conclude that he has been so "unsuccessful" that he should not even call himself an engineer.

But the conversion factor between engineering success and financial success is not a constant. Before a man jumps to conclusions about the one based on figures from the other, he should define engineering success in its own terms.

For instance, we talk about "gain" of amplifying equipment—the boost given to an input signal. The engineer starts with an input which is the knowledge developed by previous generations plus the education to use and extend it. His gain is the boost he can give this input, to produce an output which advances the art and science of engineering.

The businessman starts with invested capital as input; therefore his gain is properly measured in terms of money. A successful businessman is a prosperous one, almost by definition. But a successful engineer is not always prosperous.

The nonprosperous engineer may be the victim of exploitation, of his own inability to sell himself, or of a number of things, including "the breaks." Those who feel they belong in this category should take a long, hard look at their own engineering "gain," as well as at their level of responsibility.

Some may conclude that, after all, their salaries simply match their performance. Others may decide that the time has come for action—self-improvement, job-seeking, or a bold bid for recognition—to correct any disparity between success and prosperity.

Colin Carmichael

EDITOR

One of seven small-scale computers used as "satellites" to two large-scale systems. This method provides ready access to a central computer system, and promotes its use by the engineering staff. Photo, courtesy Douglas Aircraft Co., Santa Monica, Calif.

A "second-generation" computer—the Bendix G-20 system. Photo, courtesy Reaction Motors Div., Thiokol Chemical Corp., Denville, N. J.

A computer isn't just an overgrown slide rule or desk calculator. It's an extension—admittedly an expensive one—of the engineer. And since it is such an important part of the engineering organization, careful plans should be made so that its integration into the system is as easy and painless—and profitable—as possible. Here are some ground rules that will help in establishing a happy relationship between man and machine.

Learning to live with a computer

DAVID C. EVANS
Director of Engineering
Bendix Computer Div.
The Bendix Corp.
Los Angeles, Calif.

THE general-purpose digital computer is the most powerful and versatile tool ever made available to engineers. In addition, the initial investment involved in setting up a computer installation has the greatest potential for increasing returns of any innovation that can be brought into an organization.

A computer represents, in most cases, the largest single capital expenditure that will be made by a company, except for the plant itself. Yet present rental plans tend to distort perspective regarding its cost and significance (approximately $1500 per month for a $50,000 computer, and $15,000 for a $500,000 computer). Management would never buy a $50,000 lathe or a $500,000 punch press without thorough planning for its location, use, integration into the manufacturing system, and for an operator-training program. Yet, management will sometimes set up a computer installation with only a minimum of planning and with haphazard supervisor selection.

Interest and attention of top management, along with careful planning, are vital to a successful computer operation. How the supervisor will be selected, what procedures will be adopted for the computer's use, where the computer will be located, what type of training program will be set up, what printed forms will facilitate efficient use—these are some of the things that determine the degree of success of a computer installation.

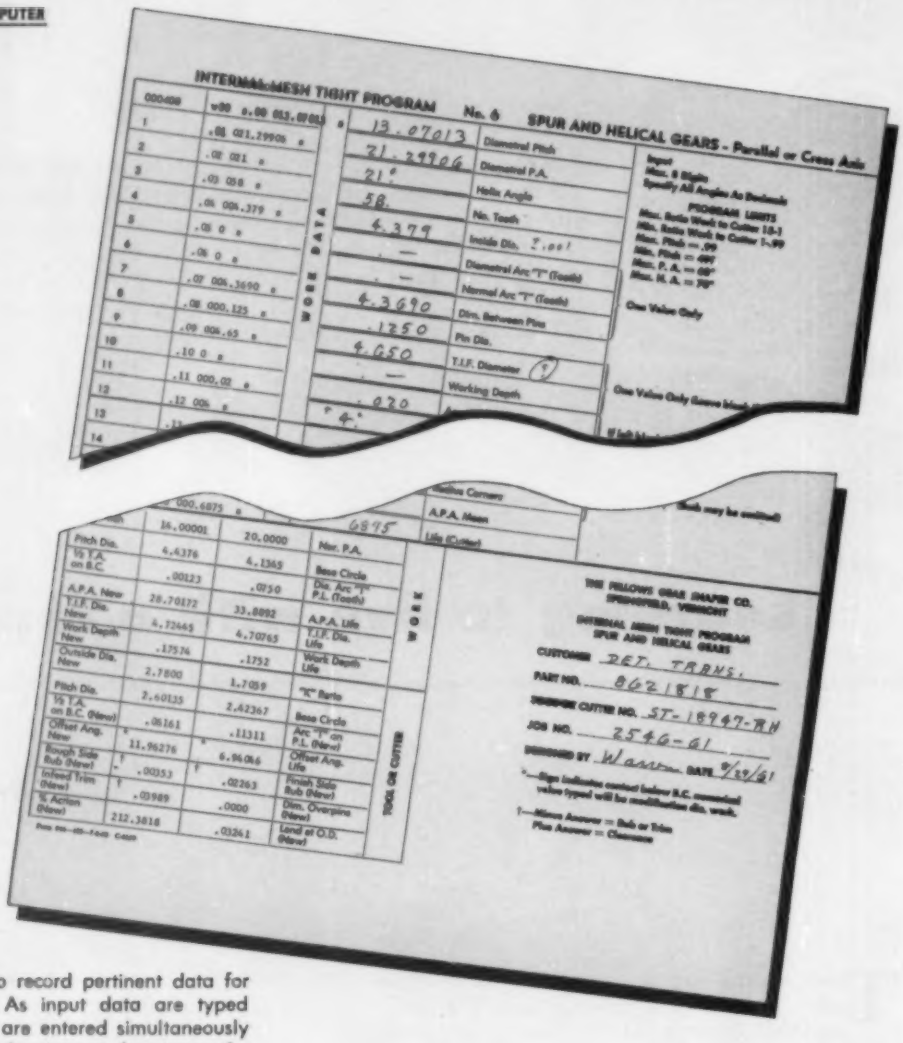
Management Attitude

A computer is only as good as its output. It has to be used for the right problems. It is not a substitute for engineering or thinking—rather, it frees engineers for engineering. For this reason, the red tape associated with using the computer should be done away with as much as possible.

The paper-work necessary to get computer time should be kept to a minimum. Also, a realistic charge rate should be set up. Engineering groups are not willing to be billed high for the use of a tool with which they are just getting acquainted, and of whose suitability they may not yet be convinced. High rates may also restrict use of the machine to problems that the engineers know will "pay," and may discourage development of new projects.

Elaborate cost-justification reports have in some cases been demanded by management. Some companies require that the computer supervisor periodically report the number of man hours saved by the computer. This is an unrealistic evaluation of an installation. In many cases the work being done would not have been done without the computer,

Circle 22-2 on Page 19 for extra copy.



Typical form used to record pertinent data for a given problem. As input data are typed onto the form, they are entered simultaneously into the computer. A print-out then types the answers in the designated spaces.

and the methods used are different than those that would have been used otherwise. As an example, some computers are run unattended at night for heavy and repetitious mathematical procedures.

The cost justification of a computer presents a difficult problem. Materials saved, designs optimized, business undertaken that staff limitations would have prohibited, faster deliveries, and enhanced competitive position are factors that come into consideration.

Supervision

The man who heads the computer operation should be a computer enthusiast. A well-trained enthusiast is one of the surest guarantees for the success of an installation.

The newest engineer, the man no one knows what to do with, or the junior staff member are definitely not the ones to be made responsible for developing use of the computer. The installation head can be a specialist in the company's business, who is able to think in terms of computers. Or he can be a computer specialist, who is able to communicate with the engineers. In both cases, it is important that the man in charge of the computer operation does not give the impression that he is taking over the engineers' work, but is, rather, working with them.

The head of the computer operation will be called upon to adapt existing procedures to the computer, converting to new methods from the familiar ones for desk calculators and slide rules. At the same time, he must have the imagination and mental aggresiveness to see beyond the obvious. The computer manufacturer can teach a man to program and can suggest new uses, but for the most part the user should be able to recognize and orig-

The New Generation

The problems that face an engineering organization ordering a computer today are different from those of some years back. Originally, computers were large, extremely expensive systems, poorly adapted to man-machine relationships. They were difficult to communicate with and difficult to use. A well-trained specialist was necessary to program them with any degree of efficiency, and because of their formidable cost, a special operator was necessary to control the use of the machine and insure maximum benefits from the installation.

The first development to bring the computer to the engineer was the low-cost, small-scale machine. With this unit, the less proficient user could process his problem without costing the company several thousand dollars in machine time. The low-cost machines proved practical for the engineer's small problems, and provided a ready-access tool for immediate problem solution.

Along with the new machines came the development of simplified programing systems, making it possible for engineers to learn to prepare their problems without extensive training. The "open shop," where the engineer processes his own problems, became a reality. In large open-shop organizations, small-scale machines now operate as "satellites" to large-scale, high-speed systems.

Today, "executive" routines make it possible for the computer to manage its own work, scheduling programs for use with magnetic tape, punched tape, printers and punched-card equipment, and, in addition, allocating storage locations for programs and data.

"Interrupt" facilities permit the use of computer systems for the engineer's small problems. With more than 80,000 operations per second available from many computers, a small problem can be processed at the same time as a major one, without causing any noticeable delay. Some computers, on receiving an interrupt signal, can make the decision to process the work immediately, or to defer it till later. Some computers have a real-time clock, enabling the computer to schedule its own work and keep track of the load on its accessories.

Computer languages have evolved to where the operator no longer has to adapt all his concepts to machine terminology. ALGOL, the international algebraic language for computers, uses symbols and terms common to engineers.

With the newer computers, several departments can make use of a central facility by having an input-output station at their own locations. This is accomplished by transmission lines operating on the interrupt principle, making it possible for the user to get his problems in and out of the main machine without going to the central computer installation.

inate applications of specific value to his company.

Sometimes a computer is installed largely because of major production problems. In this case the programs do not have to be written by the company's personnel, and operation of the machine requires only the part-time responsibility of one of the engineers. Therefore, the company may not want to put a senior member of its staff through the manufacturer's full training program. This is false economy. An organization must have at least one supervisory staff member able to take advantage of new developments, and to make full use of the computer's capabilities.

Personnel Training

Management should endorse an active training program for its engineers. The first course should be given before installation of the machine, for group heads and representatives of each engineering section. Main purpose of the course should be to explain how to recognize a computer problem, what programing methods will be used with the machine, and the specifications of the equipment. Paper work and the procedures for getting time on the machine should be explained, and available programs described.

The engineers who attend these orientation classes may not necessarily end up writing their own programs. However, in order to make efficient use of the computer they must know the reasons for input-data requirements, the limitations and capabilities of their machine, and what is involved in programing a problem.

Following the initial class for key people, courses for volunteers should be given. These are probably more effective if given after installation of the equipment, so that a working setup can be used. Participation by engineering-staff members should be encouraged, even though at first this will mean a decrease in efficiency of the engineering operation.

Training classes seem to be most effective if kept to around fifteen people. This permits individual attention by the instructor. In one company, because the computer arrived at a time when the staff had no time available for the course, classes

Computer used in design of gear-cutting and finishing tools. This installation is used to obtain all data necessary to fill the customer's design requirements. Photo, courtesy The Fellows Gear Shaper Co., Springfield, Vt.

were held in the evening following group dinners.

These training sessions are indoctrination classes, and are not like those in which a company trains its major programers. The purpose is to introduce the computer to the engineers and to stimulate their interest in its use. Some companies post a notice asking those interested to sign up; when enough have done so, a class is scheduled. Others schedule classes periodically regardless of the number of people involved. Whatever the method, a program of some kind should be in effect, so that computer know-how and interest are maintained. When this knowledge is kept within the group assigned to the machine, there is a tendency to leave its use to them.

The missile division of a large aircraft manufacturer gives an example of the effectiveness of an active training program. This company has several small-scale computers—to support its large-scale systems—which are directly available to the engineers and scientists. The engineering staff is being trained to use the smaller equipment, using the simplified programing languages that are currently available with most machines. The first computer was installed in January, 1959; by the end of 1961 the company expects to have trained 2000 to 3000 engineers, and the forecast is for 5000 potential engineering users. The original plan was to have the computers scheduled for only 80 per cent of the available time, so that the remaining 20 per cent could be used by those having immediate need for the machine. However, the computers have been operating beyond the regular work shift and the company feels that the addition of more computers will result in the same pattern, since new uses for the equipment will be found.

Along with the education program there should be a periodic bulletin put out by the computer group. This should describe new programs, modifications of old ones, and new applications of existing programs. Also, a good program library—a collection of routines for problem solving — is essential.

Working Forms

Forms should be adopted to make the computer output useful both to engineers and to others needing it—for example, manufacturing and sales. Computers can be programed to print answers in specific places on a page. In this way, they can appear on prepared forms, properly identified, and may be used directly by those needing the information. Reproducible forms make multiple copies a simple procedure.

Efficient programing sheets — the forms used in writing a computer program—not only make it easier for the engineer to write his program, but also reduce the possibility of error. Standard sheets are supplied by the manufacturer, but in some cases a company has special requirements that may suggest special forms.

Once a program has been written, it should be recorded, complete with operating instructions and any boundary conditions, so that others besides the originator can make use of it. By having the required information specified on printed forms, there is less chance that a program's usefulness will be limited to the writer.

Typical Installations

While the preceding recommendations are of a general nature, the specific experiences of two different engineering organizations may be of additional interest. The first company is relatively small, and operations are centralized. The second is extensive, and operations are conducted in a number of widely spaced locations.

Case 1: This computer installation, set up in 1955, is used in the design of gear-cutting and finishing tools, master gears, cams, cam cutters, and in making up tables of values and functions. A special program uses magnetic tape to store data on 25,000 tools. When a new order is received the tape is searched to avoid duplication of engineering effort.

Forms have been printed by the company for use in the computer typewriter. As input data are manually typed onto the form it simultaneously enters the computer. Format instructions are included in the programs, and the computer types out the an-

The Head Man

Who's the right man to head up the operation? It goes almost without saying that he should be enthusiastic about the idea of putting the computer to work in the organization. But enthusiasm isn't enough. Here are some of the more important attributes the supervisor should have:

- **Versatility.** The supervisor will be called upon to adapt existing procedures to the computer—no mean task if he meets with resistance from the engineering staff. At the same time, he must have the imagination and mental aggressiveness to see beyond the obvious to more sophisticated uses for the computer.
- **Advanced Mathematical Training.** This is a big help in applying new and advanced mathematical procedures to old and new problems, in order to take full advantage of the computer's capabilities.
- **Familiarity with Company Operations.** Another obvious requirement. The supervisor can't hope to do an efficient job of adapting the computer to the company's operations if he doesn't know what those operations are.
- **Familiarity with the Engineering Staff.** The head of the operation should know his men—who are the aggressive thinkers, which engineers are willing to try something new, and which will fight to the last shell to save outmoded methods and procedures.
- **Well-Rounded Personality.** The supervisor won't always be the most popular man in the organization. But he should be able to get along with people, and command their respect.

swers in designated spaces and columns.

The biggest problem the company had to overcome was that of being green to computer usage. It was, therefore, several months before full advantage could be taken of the installation. As those assigned to the computer became familiar with the requirements for translating an engineering-manufacturing problem into computer language, the initial program—written by the computer manufacturer—was improved and new programs were written.

The second problem to confront the company, and one that persisted to some degree, was that of clearing up confusion among the engineers regarding forms used by the computer for recording the data entered into the machine and for identifying its output. Forms now specifically label and identify each item of data involved.

One problem that came up occurs in most computer operations. Computer programs use complete and precise information. Answers can only be as accurate as the information provided. For example, if an engineer knows that nine times out of ten an angle is 2 deg, he will leave the calculation out. In a computer program, which may be run hundreds of times, the angle is calculated each time, in order to cover the time when it will not be 2 deg. Where approximations were formerly made with curves, the computer goes through the complete geometric or algebraic procedure and prints out precise answers for the different gradients. The engineer must learn to furnish the computer with complete and accurate initial data, and to make use of precise output values.

Case 2: In this installation, a large number of engineers in decentralized locations are involved in a variety of problems. The computer installation is manned entirely by engineering personnel chosen from the company's regular engineering organization. The computer is looked upon simply as a tool for the engineer. Thus, a tour of duty in the computing group is a standard engineering assignment.

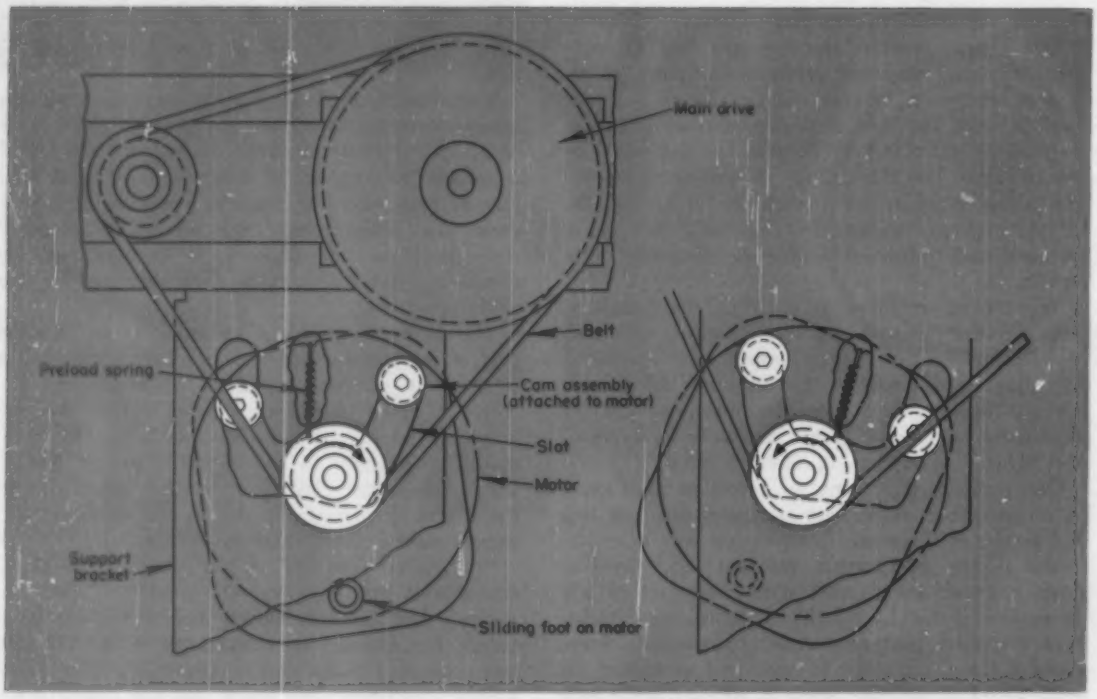
To solve the problems which came up when the computer installation was first set up, three areas of activity were undertaken: 1. Routine training of engineers to supplement the technical personnel already experienced in computer operation. 2. A program for disseminating the results of research throughout the organization. 3. Arrangements for completing computer-service work requested by the engineering staff.

The computer training program is an integral part of the over-all one-year training program that is given to all new engineers. The program involves a series of formal lectures during the engineering school, and a subsequent two to four-month assignment in a computing group, during which the engineer receives practical experience in the use of the computer and in the methods presented during the formal instruction.

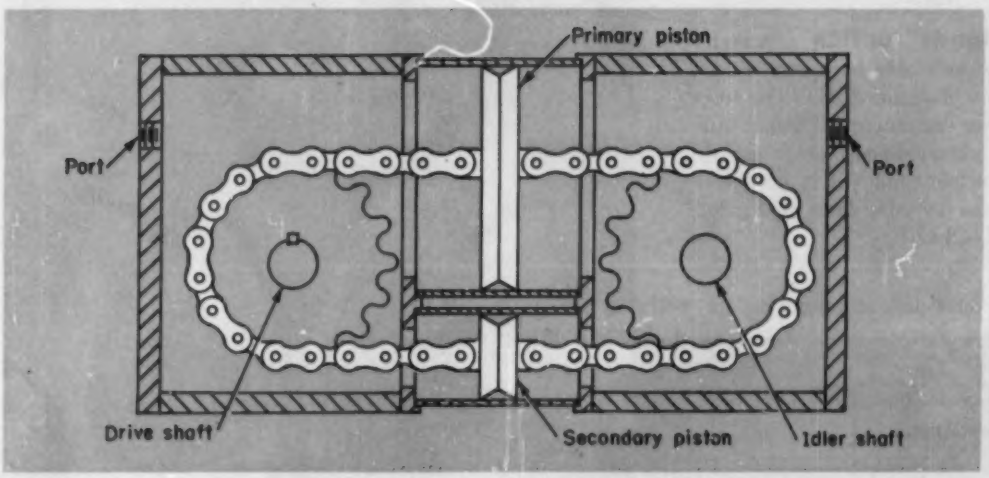
Information obtained on the computer is made available to any engineer who needs it. When an analysis has been developed and a suitable procedure formulated, the information is quickly put into company information channels. This puts specific computer applications into the hands of all engineering personnel, and serves as a guide to available applications and as a means of keeping technical personnel abreast of new developments.

During the last three or four years, a much greater increase in productivity was achieved than in the early stages of the computer operation. During early stages, a formal training program was being inaugurated, and the percentage of engineers with computer experience was almost negligible. Lately, however, the trend in the increase of productivity with the increase of experienced personnel is unmistakable. One of the major reasons for this seems to be the ready acceptance of the computing service as a valuable tool by the engineering staff. • • •

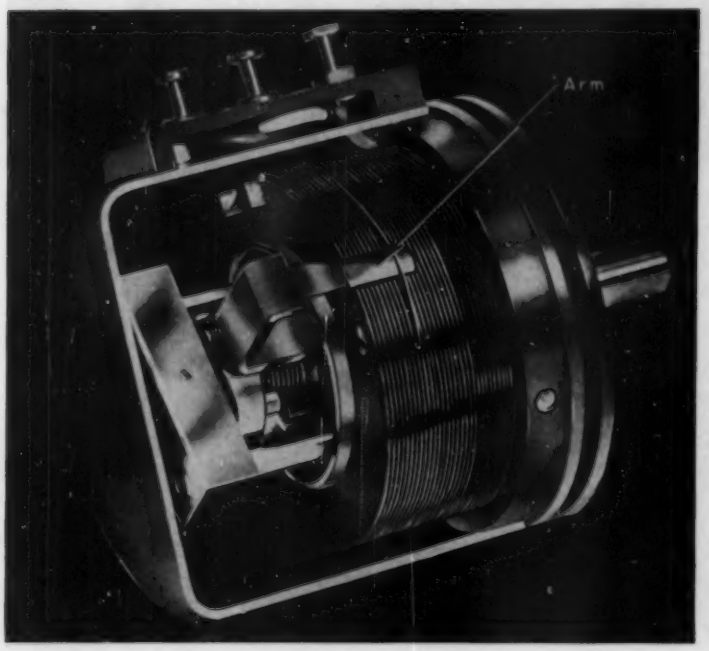
SCANNING THE FIELD FOR IDEAS



Reaction controls tension in an electric-motor V-belt drive. Dual slots on the motor mount permit reaction torque of the motor in either direction of rotation to provide belt tension in proportion to the load. Principle employed in a washer motor mount by Norge Div., Borg-Warner Corp., Herrin, Ill.

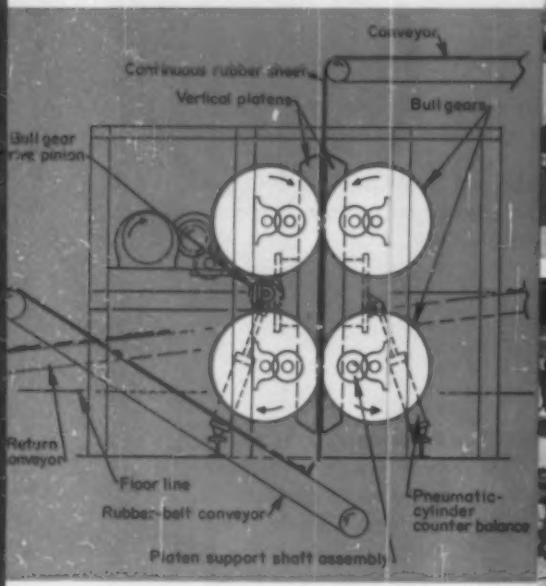


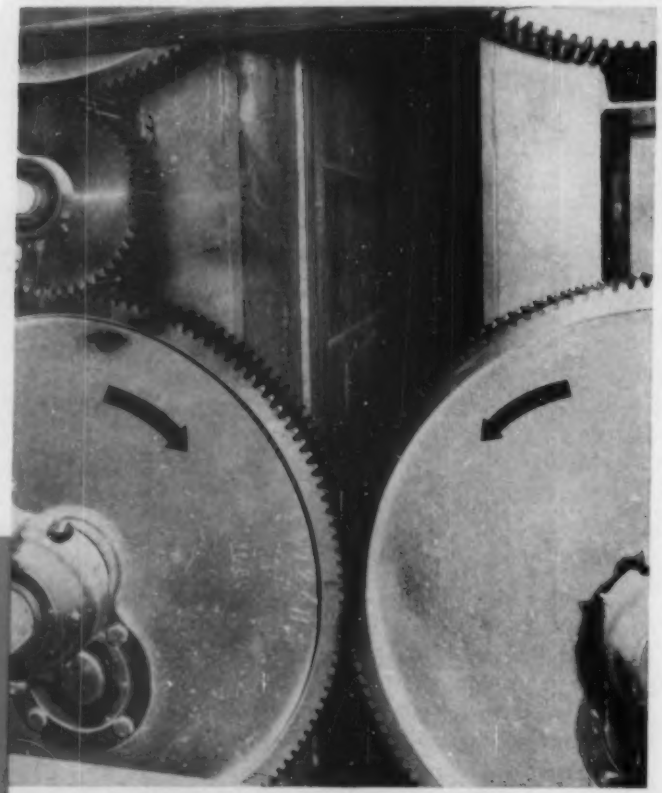
"Recirculating" piston rod is formed by a continuous chain loop in a hydraulic actuator. Thus, additional space for the extension of the piston rod is not required. Principle employed in an actuator by Graham Engineering Co., Palo Alto, Calif.

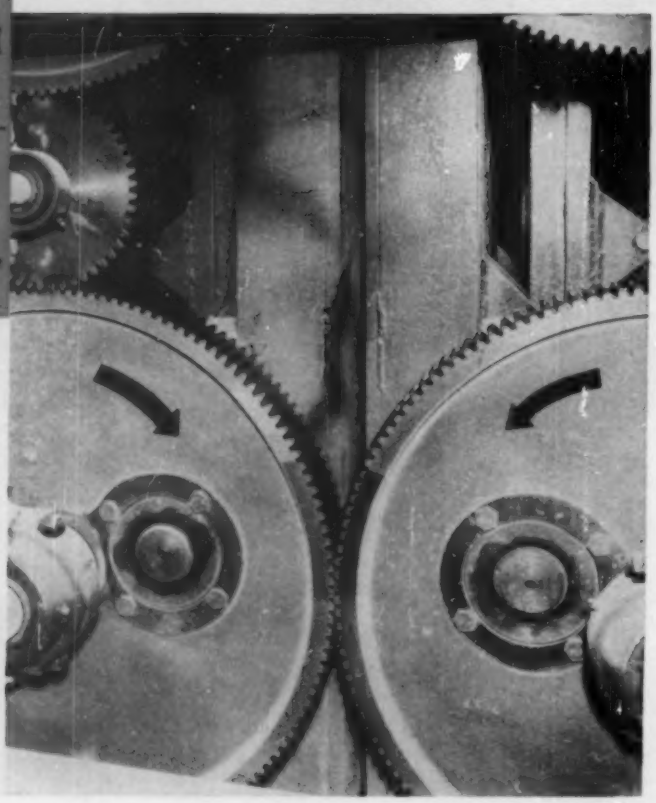


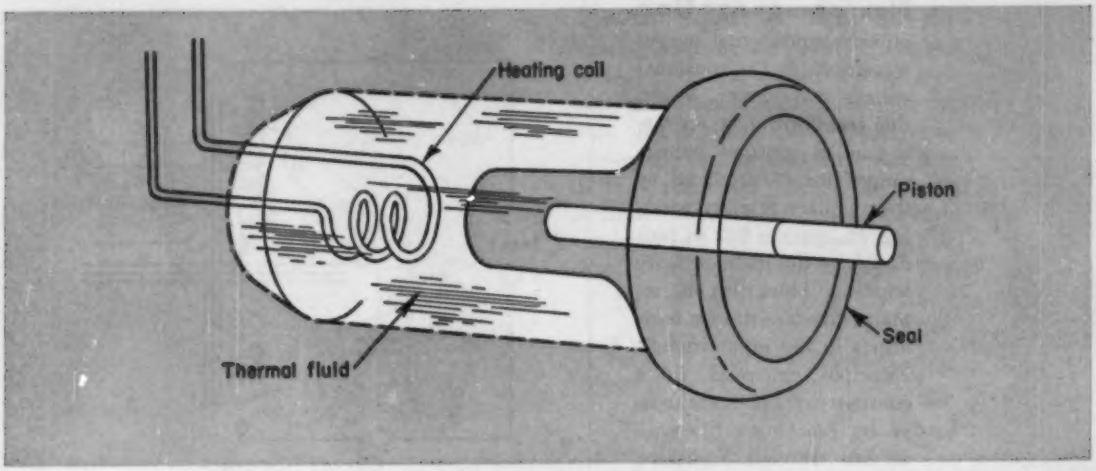
Arm supports wire in a multiple turn potentiometer. As the arm is rotated, a single strand of the resistance wire is lifted from coil, passed over the arm and returned to the coil. Principle employed in a potentiometer by Vogue Instrument Corp., Brooklyn, N. Y.

"Clap-hands" action of a vertical platen press cancels reaction forces and assists material feed. The two platens are mounted to eight bull gears by platen-support shaft assemblies. Principle employed in a vertical platen press by May-Fran Mfg. Co., Cleveland, Ohio.



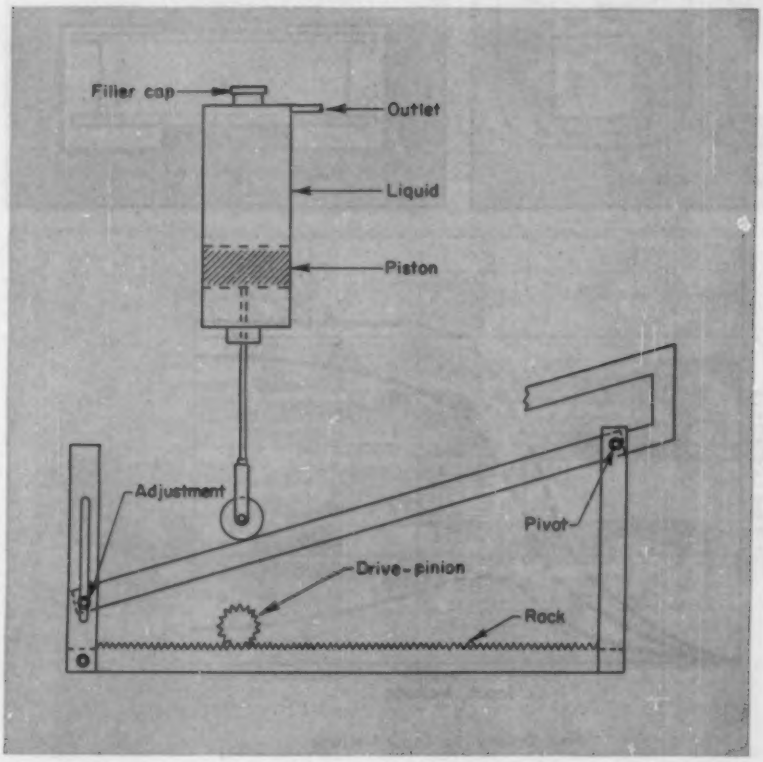




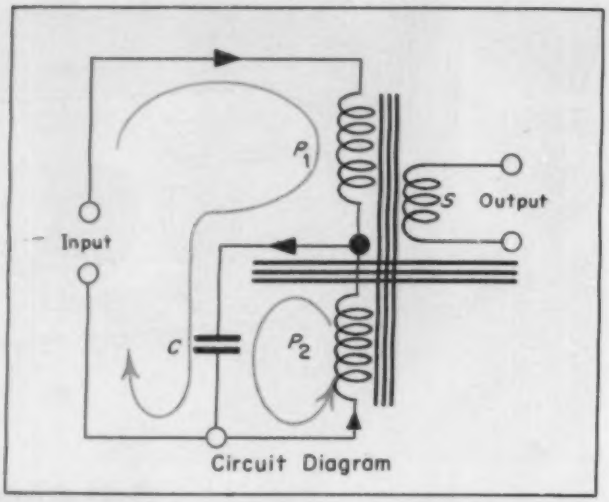


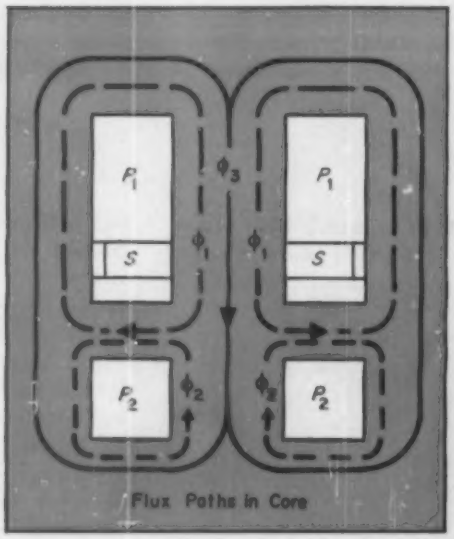
Heat drives piston in an electrothermal actuator. Electrical energy, applied to the heating coil, expands the thermal fluid, which in turn, drives the piston. Principle employed in an actuator by Standard-Thomson Corp., Waltham, Mass.

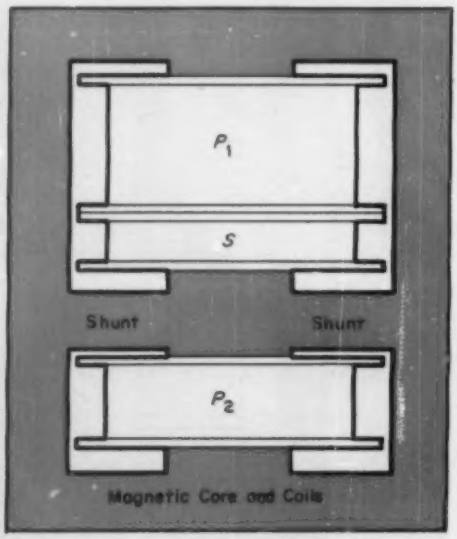
Incline controls flow from a single stroke cylinder-type fluid dispenser. With the rack in the extreme right-hand position, the lower end of the incline is adjusted vertically so that the fluid level coincides with the top of the cylinder. Then, as the rack is driven through its stroke by the pinion, the fluid is forced from the cylinder at a uniform rate. Thus, any desired quantity of fluid can be dispensed at a uniform rate during the complete stroke of the rack. Principle, used in a liquid fertilizer distributor, reported by J. G. Futral in August, 1961, *Agricultural Engineering*.

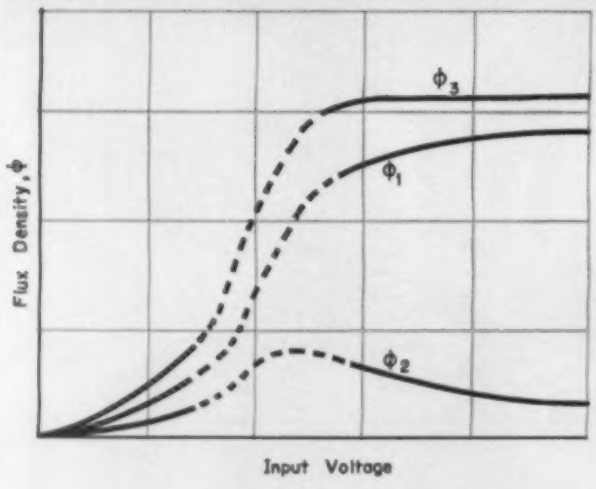


Flux compensation provides undistorted output waveform in a constant-voltage transformer. When the transformer is operating in its constant voltage range, flux Φ_2 produced by the auxiliary primary winding, P_2, opposes flux Φ_1 produced by the main primary winding. Thus, flux Φ_3 remains constant despite variations in the input voltage. Principle employed in a constant-voltage transformer by Blackburn Electronics Ltd., Brough, Yorkshire, England.

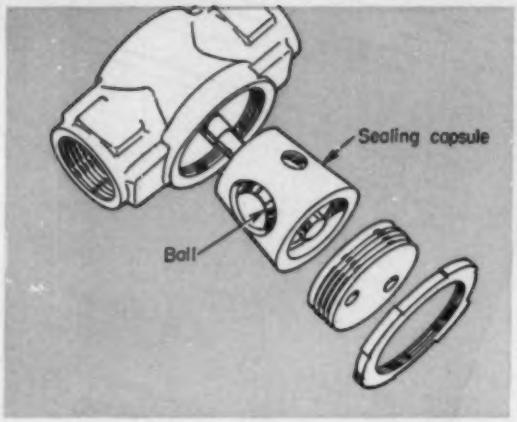




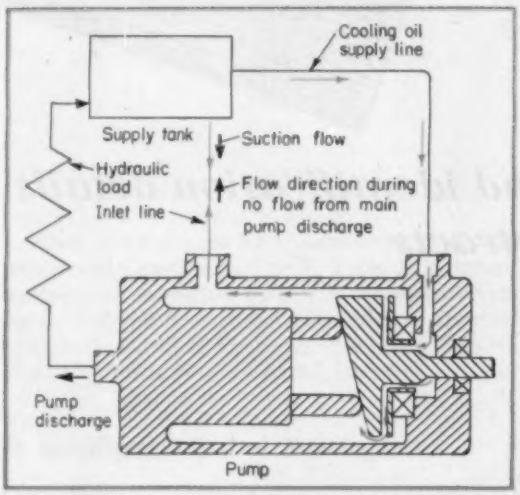




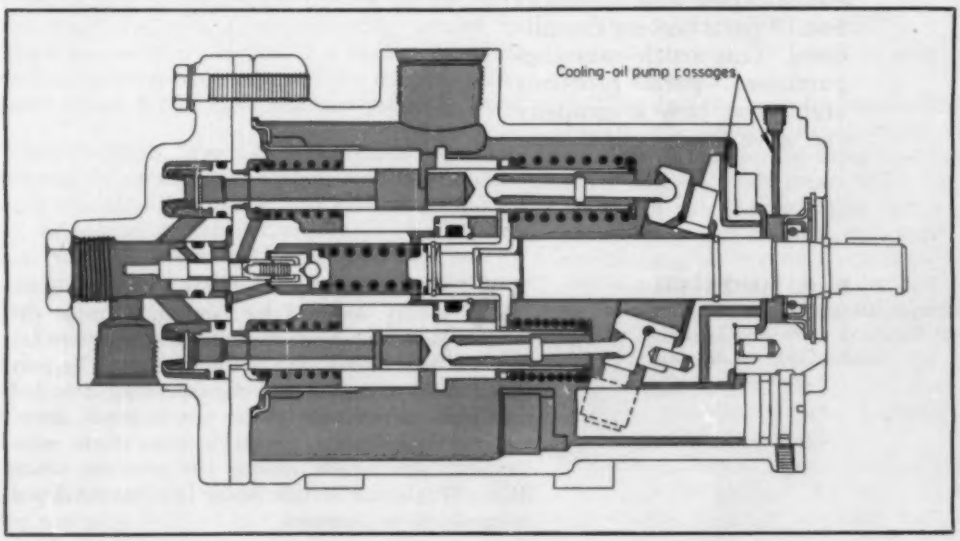
Flux Density vs. Input Voltage

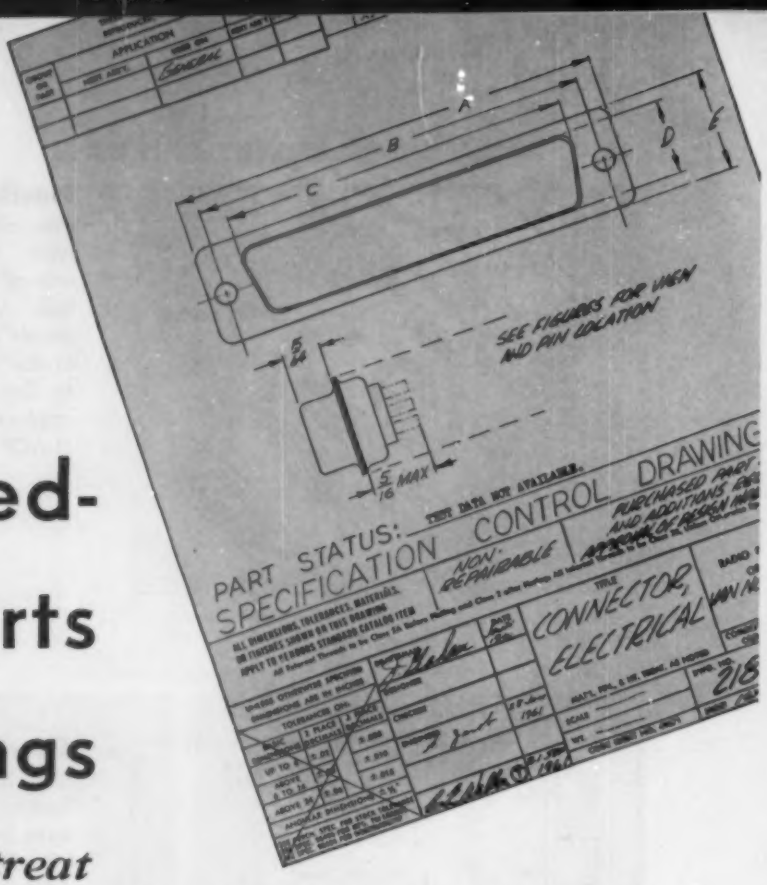


Plastic squeezes ball to provide adjustment for wear in a ball valve. A conical-shaped sealing capsule of Teflon is molded around the ball. An adjustable base plate compresses the capsule into a tapered bore in the valve, thus forcing the plastic to flow around the ball. Principle employed in a ball valve by WKM Div. of ACF Industries Inc., Houston, Tex.



Flow-direction reversal in the inlet line of a variable displacement hydraulic pump permits the line to serve as a return passage for cooling oil when there is no flow from the main pump discharge. Passages drilled in the pump-drive cam serve as a centrifugal pump to provide a flow of cooling oil. If there is flow from the main pump discharge, this cooling oil is added to the suction flow supplied through the inlet line. Principle employed in a pump by Weatherhead Co., Cleveland, Ohio.





Purchased-Parts Drawings

How to treat specification and identification details in military contracts

Parts purchased from vendors pose problems quite unlike those for parts made inside the plant. Particularly in military contracts, and when vendors are many and varied, identification and specification of parts become complicated. This article examines purchased - parts problems and shows how a company can solve them.

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WHEN a part for a military contract is completely designed for fabrication inside the plant, requirements are fairly straightforward and well understood. But if the part must be purchased from a vendor, and the contractor does not specify the construction of the part in detail, drawing and specification details become much more complex. This article outlines the practices which RCA's Missile and Surface Radar Div. has developed to handle these problems.

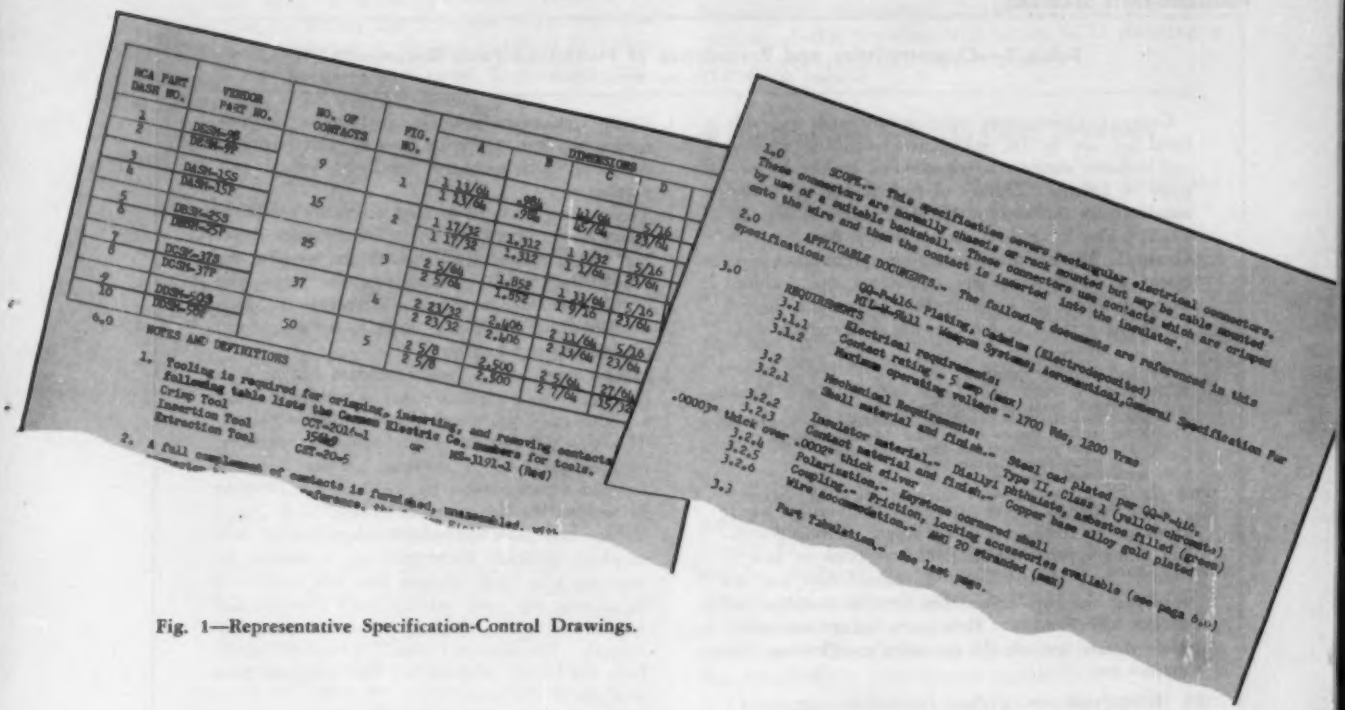

Fig. 1—Representative Specification-Control Drawings.

When there is need for a part which is unavailable in military Groups I to V, Table 1, it becomes necessary to list such a part by a vendor part number or to depict it on one of three types of drawings: Specification-Control Drawings, Altered or Selected-Parts Drawings, Source-Control Drawings.

• Specification-Control Drawings

An SCD is a contractor's drawing for any part, the detail design and manufacturing process for which are under the control of a vendor, regardless of the original source of the need for the part. Characteristics of SCD's have stemmed primarily from:

MIL-D-5028B, "Par 3.4.4.3 Contractor's specification-control drawings . . . [shall reflect] . . . complete identification, source, and revision data . . . for commercial or patented articles . . . Such drawings shall be submitted to the procuring activity together with the design manufacturer's engineering drawings.

"Par. 6.2.3.9 Contractor's specification-control drawing[s] . . . [are] . . . defined as information in drawing . . . form setting forth the contractor's general requirements for an item to be fabricated under vendor's part numbers . . . these shall be considered as commercial or proprietary items, with the control drawings . . . number not considered [by the procuring activity] as a part number but only as a 'dummy' number assigned for the convenience of the contractor."

MIL-D-70327, the governing specification on new contracts, refers to MIL-STD-7, "Par. 3.24 . . . A specification control drawing discloses configuration, design and test requirements for the item . . . designed and manufactured by vendors. Vendor's part numbers, names and addresses are included on the drawing. A specification control drawing number is not considered a part number."

"Par. 3.6.2.2.1 [MIL-D-70327] . . . specification control drawings . . . shall be submitted with the set of drawings."

What does this mean to the drafting department? Plainly, the military would prefer to see vendor numbers directly on the using assembly lists of material. MIL-D-5028B wants SCD's kept to a minimum. All specifications agree that an SCD is not considered a part number and require special notes on the using list of materials to this effect. Provisioning-Parts Breakdowns (spare parts lists) are required to list parts by vendor part numbers. SCD's, if listed, are for reference only.

The minimum which will permit the satisfactory procurement of parts is an SCD for any vendor part which is not identifiable by a military or an industry standard number, Table 2.

There are two different situations under which an SCD may be initiated. The most common instance arises when a design engineer looks in a vendor

Table 1—Characteristics and Precedence of Purchased-Parts Documents
Sources: MIL-STD-143 and MIL-D-70327

Group I—Government specifications and standards listed for use by the government requiring activity, and industry documents co-ordinated by the Department of Defense. Indexes of such specifications and standards are included in MIL-STD-143 and MIL-D-70327. The latter lists such industry documents in Group II. Military drawings are not specification pages except when drawings are reproduced and included in a specification. Part numbers are usually derived by adding a suffix to the drawing or document number.

Typical military drawings are:

MS 63045, Plate, Marking, Blank
AN 5535, Resistor-Adjustable Thermocouple Lead
AND 10375, Colors-Fluid Line Identification
AF 51B13712, Receptacle Coax, UG-680/U
SC-A-21825, Identification Tag
REE 10006, Contact

Type designations are parts identifications for which there are no corresponding drawings. Certain governing military parts specifications give rules on how to "build" type designations. However, they are not true part numbers unless they provide complete and unique identification. Their parts listings are incomplete without quoting the governing specification. Examples are:

RC20BF680K Resistor Fixed, Composition, (MIL-R-11)
JAN-7077 Electron Tube, Receiving, Triode (MIL-E-1)

Group II—Industry specifications and standards listed for use by the government requiring activity, for which status equivalent to military documents has not been established. Such items are "promulgated by nationally recognized associations, committees and technical societies." They specifically exclude "company specifications and standards" which are described under group V.

Group III—Government specifications and standards not previously listed by the requiring activity (e.g., a Signal-Corps standard used on an Air-Force contract).

Group IV—Industry specifications and standards not previously listed by the requiring activity.

Group V—Company specifications and standards. Such documents are made up by a design contractor's standardizing department to provide his designers with part numbers for parts which are not available under Groups I through IV. As soon as a part becomes available in one of the higher-precedence groups, the company-standard reference should be dropped.
There are three kinds of company standards in Group V:

1. Purchased part — an item which is ordered on a list of material in a numerical quantity.
2. Bulk material — an item for which quantity on a list of material is expressed "as required."
3. Raw material — an item which is not ordered on a list of material but on a fabricated-part drawing. Such items, like "bulk materials," cannot be ordered in simple numerical quantity.

Group V also includes the following items and purchasing circumstances:

1. Vendor standard item chosen from a vendor's catalog or from a vendor drawing, and having a completely and uniquely identifying vendor part number.
2. Vendor item designed to meet contractor's requirements is completely defined on a contractor's drawing which, during negotiation stages, specifies the general operational parameters of the part. The drawing should bear the words "Provisional Specification Control Drawing" prior to the assignment of a vendor part number.
3. Vendor item from a vendor-standard line of parts in which the variations may be unlimited (e.g., a multibutton, multilegend, push-switch actuator). This type of part is usually made to contractor requirements from a standard vendor line and assigned a part number by the vendor at the time he receives the first purchase order.
4. Vendor item from a vendor-standard line of parts in which variations are limited (e.g., a standard instrument gear with constant hub and tooth configurations, but with varying pitch diameter and numbers of teeth). The item is depicted on a contractor's Specification-Control Drawing which, from the outset, tabulates all the catalogued parts available in the series.
5. Altered item — military, industry or vendor-standard part — which is rework-altered from its original configuration (e.g., a meter is painted a special color).
6. Selected item — military, industry, or vendor-standard part — selected from a production lot from some tighter-than-standard operational or dimensional characteristic. Its drawing bears the words "Selected-Part Drawing."
7. In-process altered or selected item which cannot be reworked from an existing military, industry or vendor-standard item, is delineated on a Specification-Control Drawing. The vendor is required to reidentify the part and to prepare a drawing defining it.
8. An item which is the same as an existing MIL, industry, or contractor item except that the existing item is subject to optional characteristics, not all of which are acceptable, and the unacceptable characteristic cannot be eliminated by alteration or selection. The item is depicted on an Elected-Option Drawing.
9. Make-or-buy item, which is completely delineated as to dimensions, material and finish, such that any competent fabricator could make the part, is delineated on a contractor's Fabrication Drawing. This permits the contractor to procure from the vendor, but does not require procurement of vendor drawings and usually results in lower costs through competitive procurements.
10. Part made from vendor proprietary raw stock (e.g., gasket cut from a vendor's standard extrusion; hinge cut to length from a vendor standard blank).
11. Part made to contractor's requirements in accordance with a vendor's proprietary process (e.g., a designation plate made from a vendor's lamination process and material — the size and content, strictly to contractor's requirement).

catalog and says, "I want that one!" Instead, the order of precedence for the selection of parts should be: 1. Project preferred. 2. Project standard. 3. Other MIL parts. 4. Industry standards. 5. Existing company standards. 6. Vendor catalog parts. A vendor catalog will often list the only part which will work, and the result is an SCD which calls out the part by vendor name and part number.

On the other hand, the engineer goes through this screening process and finds nothing he can use. The result will be a specification drawing. In this case, however, the engineer can call out only the parameter requirements for the part, thus providing the purchasing department with a shopping license to find a vendor who can produce a special part. Negotiations and compromises on design requirements will be reflected in changes to the drawing. The final version of the drawing will be an SCD showing a firm vendor name and part number.

Table 2—Functions of Specification Control Drawings

1. The SCD controls the specification of the part to prevent the vendor from changing it or making it noninterchangeable with other parts previously bought under the same SCD part number.
2. If product performance has been exaggerated, the SCD either forces the vendor to substantiate his claims or it disqualifies him from supplying the part.
3. The SCD permits the contractor's engineering department to collect in one place all the vendor guarantees concerning the part. The SCD also provides a condensed statement of requirements.
4. If the contractor conducts an evaluation of a part and determines that it has certain capabilities (or weaknesses) in addition to those stated by the vendor, the SCD provides a file number for storage and ready access to these data.
5. For internal reference, the contractor's engineering department can use the SCD to specify such details as approved mounting dimensions interface data, mating part numbers, and application information.
6. The SCD provides engineering and documentation systems with readily available information concerning each vendor part.
7. The SCD provides a common identifying number for a part which may be procured from more than one vendor.
8. Where no vendor is initially known, the preliminary SCD (or sketch) is a "shopping license" for the contractor's purchasing department.
9. The SCD provides the contractor with a part number which will not change. The contractor cannot afford to initiate the change paper work required to reflect, throughout his drawing and procurement system, a change in part number introduced by a vendor. Instead, one simple change to the SCD is all that is necessary.
10. The SCD provides the contractor's inspection department with an authoritative document against which to inspect incoming parts. The SCD can properly spell out (or refer to) test and quality assurance provisions.

● Altered and Selected-Parts Drawings

There are, effectively, two types of alterations: In-process alteration and rework alteration.

In-process alterations create new vendor parts. An in-process altered part should be defined on an SCD by calling for the part as manufactured, identified, and marked by a complete, distinctive, vendor part number. There is no harm in including a "same-as-except" note on the SCD, but this note should be labeled "For reference only," and the differences should be noted.

Rework alterations are vendor parts which have something done to them after completion. Two contractor part numbers are required: 1. An SCD part number defining the unaltered vendor part. 2. An altered part number stating "Same as . . . except . . ." or "Make from . . ." plus a complete and exact description of the alteration (including marking with the contractor's altered-part number).

These rework remarks apply to any vendor part which is altered by or for the contractor, under the contractor's part number. If, however, the vendor chooses to assign his part number to his item, and prepares a drawing showing it as reworked, the reworked part becomes another SCD item.

Selected parts are handled like altered parts, but there are certain subtle differences. If a part undergoes rework selection (e.g., selected for certain tighter-than-usual characteristics), the segregated part is reidentified and marked with the contractor's selected-part number. As with rework-altered parts, two part numbers are required: 1. An SCD number for the item prior to selection (and also for the culls following selection.) 2. A selected-part number whose drawing describes exactly and completely the selection process to be performed. Frequently, both parts can be tabulated on the same drawing.

It is also possible to perform an in-process selection (e.g., a standard transistor type, with special, stringent quality assurance provisions). As with an in-process alteration, this procedure requires an SCD to define the part and to list the completely and uniquely identifying part number assigned by the vendor.

These requirements are summarized in Table 3. While the foregoing discussion has treated altered and selected vendor parts, these requirements apply equally to altered and selected military and industrial standard parts.

● Source-Control Drawings

According to MIL-STD-7, Par. 3.23, a source control drawing specifies the source which exclusively

provides the performance, installation, and interchangeability characteristics of an item that has been selected and tested for a specific application.

The drawing is identified by the name and part number of the contractor design activity and must show the vendor's name, address and part number and shall also contain the following notes: "Only the item[s] listed on this drawing and identified by vendor's name[s], address[es], and part number[s], have been tested and approved by [name of the equipment design activity] for use in [name of item]. A substitute item shall not be used without prior testing and approval by [name of equipment design activity]."

Since a Specification-Control Drawing is intended to control the specification of a part, it follows that a Source-Control Drawing should control the source of the part. Furthermore, it controls the source for a specific project which must be named on the Source-Control Drawing.

At this point it is necessary to explain that RCA's procurement system requires that a part be purchased only from the vendors whose names and part numbers appear on the Specification-Control Drawing. When Purchasing wishes to procure from any other source, they initiate paperwork to procure Engineering approval. Before giving approval, the responsible engineer must assure the proposed new vendor's capability. Upon approval, the new vendor's name and part number are added to the drawing.

Concomitantly, if a listed vendor loses his capability to produce satisfactory parts, his name and part number are removed from the drawing.

If an existing Specification-Control Drawing lists only one vendor, Purchasing is constrained from buying from any other source without Engineering approval. In this case, there is effectively no difference between a Specification-Control Drawing and a Source-Control Drawing.

Two conditions require a Source-Control Drawing. If a Specification-Control Drawing listed two sources, and there was a subtle but functional difference between parts made by the sources, a Source-Control Drawing might be needed to limit procurement to the first source only, for that application only. The new source-controlled item would bear a different contractor part number than the same item procured from the Specification-Control Drawing. Unfortunately, it is not likely that such parts would be kept separated in logistics systems. This is one reason why there seems to be little justification for Source-Control Drawings in the system.

● Drawings-Control System

Preparation and maintenance of purchased-part drawings (whether SCD, altered, or selected parts) can be assigned to a group called Design-Support Engineering.

The Design-Support approach to purchased-part

Table 3—Requirements for Identification of Parts Made by Vendors

Type of Identification	Type of Part		
		Altered or Selected	
	Vendor Standard	Rework	In-Process
Drawings from contractor:	SCD showing vendor-standard part number	SCD showing vendor-part number for the unaltered part. Altered-part number showing exact rework.	SCD showing the vendor-part number for the special altered part.
Drawings from vendor:	Drawings adequate to permit the government to reprocure the same part, and to maintain the part, if repairable.	Vendor drawing of the unaltered part.	Vendor drawing adequate to enable the government to procure the same part complete with all in-process alterations or selections.
Part number by which contractor procures and inspects:	SCD-part number	Altered-part number	SCD-part number
Part number by which government procures and stocks:	Vendor-part number	Contractor's altered-part number and/or Federal Stock Number	Vendor-part number
Part number marked on part:	Vendor-part number	Altered-part number (standard number obliterated)	Vendor-part number (standard number obliterated)

Table 4—Rules for a Purchased-Parts Drawing System

The same as the body of this article, these rules originated in a system based mainly on design of military items.

Part Number Marking

1. On vendor-designed parts, mark vendor's name, trademark, or identification code, followed by a completely and uniquely identifying vendor part number.
2. Do not mark Specification-Control part number on any part.
3. On altered or selected parts — MIL, industry or vendor-standard parts — mark the name, trademark, or identification code of the activity responsible for performing the alteration or selection, followed by a completely and uniquely identifying part number assigned by that same activity. Obliterate any part-number marking which identified the part prior to alteration or selection. If that is not possible, suffix the marking with the letters MOD (meaning modified).

Drawing Arrangement

1. Make drawing 8½ × 11 in. (A-size) or whole multiples thereof. Use pica type size for typewritten contents.
2. Delineate the part with physical dimensions, mounting cut-out, detail interface information, schematics, etc.
3. Arrange contents in paragraph order, as defined in MIL-S-6644:
   a. Application Notes (scope) — A brief description of capabilities of the part, limitations, mating parts, etc.
   b. Referenced Documents — A list of all drawings and specifications referenced in the drawing. This list enables Purchasing to send complete specifications to vendors.
   c. Requirements — A tabulation of all electrical, mechanical, environmental, and marking requirements.
   d. Quality Assurance Provisions — Any inspection, test, or sampling requirements.
   e. Vendor Information — Complete vendor name, identification code number, address, drawing or catalog, date of revision, and the unique and completely identifying part number of the item being specified.
   f. Notes.
4. If the part is one of a limited family of suitable vendor standard parts, tabulate the entire family.
5. Do not invoke any requirements which the vendor has not already guaranteed in his catalog, drawing, or signed correspondence. Particularly, this includes physical dimensions and tolerances.

drawings is to encourage standardization as much as possible. If a vendor has a line of several parts of related characteristics, the drawing should list them all in an organized, coherent tabulation. Practice has been to make the cheapest, quickest drawing which will enable procurement at the moment. Successive part requirements must be tacked onto the drawing in hodge-podge fashion or shown on a separate drawing. In time, these drawings become confusing.

A corrective approach is to make standards easy to use. To this end, Design Support exercises control over part selection at various stages of design through design reviews, nonstandard parts approval, purchased-parts drawing preparation and maintenance, release reviews, alternate vendor approval, and incoming parts inspection.

In one purchased-parts program, a file consists of prints arranged alphabetically by part name. A parts-history file consists of prints filed numerically, each print accompanied by related test reports, reliability data, vendor correspondence, change paperwork, etc. Where an obsolete company reference has been superseded by a military or industry standard, suitable cross-reference information must be included to insure that the obsolete reference is not itemized on any list of material.

Details of a purchased parts system appear in Table 4. Typical purchased part drawings are shown in Fig. 1.

A future possibility is that the military will put increasing emphasis on documents like MIL-STD-242 which invokes directly useable drawing part numbers, rather than vague references to requirements for parts identification.

They Say . . .

"Much has been written about the use of computers, automatic instruments, and other devices as the forerunners of automatic production facilities. In a few cases, the dream of fully automatic production facilities has been realized. In others, the dreamer has been shocked into wakefulness by the icy water of economics, inadequate mechanical or electronic devices, or merely because there is too little understanding of the process. We have generally accepted the premise that computers can be programmed to do such interesting things as playing chess and such practical things as spewing forth payroll checks and inventory control statistics, but these applications all have the common characteristic and prerequisite of a thorough understanding of the process involved. Without this understanding, no industry can succeed in their automatic facilities program."—J. R. Wilson, *Engineering Service Div., E. I. du Pont de Nemours & Co., Wilmington, Del.*

A new, direct approach to

Compression Spring Design

- *Cookbook design methods*
- *Slide-rule procedures*
- *Computer procedures*
- *Standard spring materials*
- *Allowable-stress data*

ROY D. CHANDLER
Standards Engineer
LeTourneau-Westinghouse Co.
Peoria, Ill.

COMPRESSION springs are usually placed in a hole or over a rod. Accordingly coil OD and ID would appear to be the most practical dimensions on which to base spring-design calculations. Conventionally, however, mean diameter is used as the starting point.

Usual approach to spring design is: 1. Assume a mean diameter. 2. Calculate a trial wire size based on uncorrected stress. 3. Determine remaining design requirements by trial and error.

Where Wahl-corrected stresses are involved, the conventional trial-and-error methods make the calculations tedious and time consuming.

The procedures outlined in this article are simple and direct. Calculations are based directly on the coil OD or ID. Assumption of a mean diameter is not necessary. The usual trial and error process in the calculations is eliminated. However, some adjustment of design parameters may still be necessary to obtain a practical spring.

● Basic Considerations

This analysis deals with four basic types of compression-spring design problems. Initial data common to all four problem types are: D_o (or D_i), P_1, and G. Other initial parameters for each problem type are (see Nomenclature):

Type 1: h_1, F_2, S_a
Type 2: F_1, F_1/F, S_a
Type 3: h_1, F_1/F, H
Type 4: H, P_1/P, S_a

Basic design objective is to determine the com-

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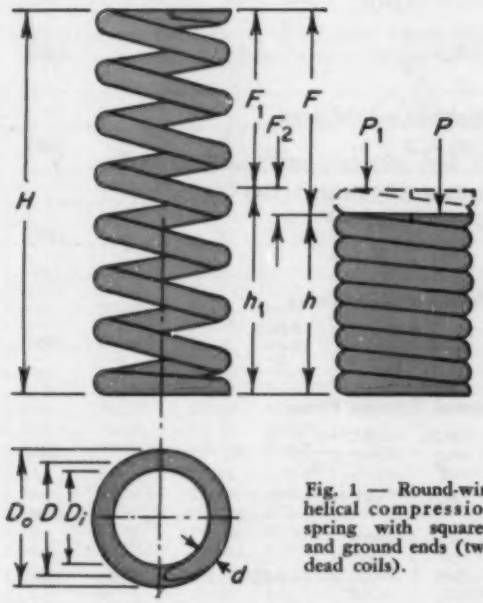


Fig. 1 — Round-wire helical compression spring with squared and ground ends (two dead coils).

patibility of the given parameters and to calculate the remaining spring "dimensions." All calculations presented here are for springs with squared and ground ends (two dead coils). Stresses incurred may be either Wahl-corrected for shear load and coil curvature or uncorrected, as desired.

In problem types 1, 2, and 4, wire size d is determined from the allowable stress, S_a. For problem type 3, wire size is determined from the working-load deflection $(H - h_1)$.

Objective of type 1 and 2 problems is to determine the lineal space (free height) needed to handle the energy requirements without exceeding safe stress limits. For the type 3 problem, goal is to determine whether or not the required energy can be safely stored in the available space. Objective of the type 4 problem is to determine the position of

Nomenclature

C_o = Modified spring index based on coil OD $= D_o/d$
C_i = Modified spring index based on coil ID $= D_i/d$
C = Spring index $= D/d$
d = Wire size, in.
D = Mean coil diameter, in.
D_o = Coil OD, in.
D_i = Coil ID, in.
F = Total deflection, in.
F_1 = Working-load deflection, in.
F_2 = Deflection from working-load position to solid height, in.
f = Deflection per coil at total load (solid height), in.
G = Torsional modulus, psi
h = Solid height, in.
h_1 = Working-load height, in.
H = Free height, in.
K = Wahl stress-correction factor
k_o = OD corrected stress factor
k_i = ID corrected stress factor
N_a = Number of active coils
N = Total number of coils
n_o = OD active coil factor
n_i = ID active coil factor
P = Total load (solid height), lb
P_1 = Working load, lb
R = Spring rate or gradient, lb/in.
r_o = OD rate factor
r_i = ID rate factor
S = Stress at solid height, psi
S_1 = Working load stress, psi
S_a = Allowable stress (working height or solid height), psi
u_o = OD uncorrected-stress factor
u_i = ID uncorrected-stress factor

Table 1—Compression Spring Design Equations

Uncorrected Stress

$$S = \frac{P}{D_o^2}\, u_o = \frac{P}{D_i^2}\, u_i \qquad (1)$$

Wahl-Corrected Stress

$$S = \frac{P}{D_o^2}\, k_o = \frac{P}{D_i^2}\, k_i \qquad (2)$$

$$S = \frac{8PDK}{\pi d^3} \qquad (3)$$

Wire Size

$$d = \frac{D_o}{C+1} = \frac{D_o}{C_o} \qquad (4)$$

$$d = \frac{D_i}{C-1} = \frac{D_i}{C_i} \qquad (5)$$

Mean Coil Diameter

$$D = D_o - d = D_i + d \qquad (6)$$

Spring Index

$$C = \frac{D}{d} \qquad (7)$$

$$C = \frac{D_o}{d} - 1 = \frac{D_i}{d} + 1 \qquad (8)$$

Number of Active Coils

$$N_a = \frac{D_o}{R}\, r_o = \frac{D_i}{R}\, r_i \qquad (9)$$

$$N_a = \frac{H - 2d}{d + f} \qquad (10)$$

$$N_a = \frac{D_o}{R n_o} = \frac{D_i}{R n_i} \qquad (11)$$

Total Deflection

$$F = f N_a \qquad (12)$$

$$F = \frac{F_1}{\left(\frac{S_1}{S}\right)} \qquad (13)$$

$$F = F_1 + F_2 \qquad (14)$$

$$F = \frac{8PD^3N_a}{Gd^4} \qquad (15)$$

$$F = \frac{P}{R} \qquad (16)$$

$$F = H - h \qquad (17)$$

Total Deflection Per Coil

$$f = \frac{P}{D_o}\, n_o = \frac{P}{D_i}\, n_i \qquad (18)$$

Total Load

$$P = \frac{P_1}{\left(\frac{S_1}{S}\right)} \qquad (19)$$

$$P = RF \qquad (20)$$

Solid Height

$$h = d(N_a + 2) \qquad (21)$$

$$h = H - F \qquad (22)$$

Free Height

$$H = h + F \qquad (23)$$

Spring Rate

$$R = \frac{Gd^4}{8D^3N_a} \qquad (24)$$

$$R = \frac{P}{F} \qquad (25)$$

Working-Load Deflection

$$F_1 = H - h_1 \qquad (26)$$

Ratio of Solid Height to Coil OD

$$\frac{h}{D_o} = \frac{N_a + 2}{C + 1} \qquad (27)$$

Wahl Correction Factor

$$K = \frac{4C-1}{4C-4} + \frac{0.615}{C} \qquad (28)$$

Special Equation Forms

$$\frac{FD_o}{P} = \frac{8C^3(C+1)}{G} N_a = n_o N_a \qquad (29)$$

$$\frac{FD_i}{P} = \frac{8C^3(C-1)}{G} N_a = n_i N_a \qquad (30)$$

$$C = \left(\frac{\pi D_o^2 S_a}{8P} - 6.0257\right)^{1/3} - 1.1217 \qquad (31)$$

$$C = \left(\frac{\pi D_o^2 S_a}{8P} + 1.6296\right)^{1/3} - 0.6667 \qquad (32)$$

$$C = \left(\frac{\pi D_i^2 S_a}{8P} + 3.8333\right)^{1/3} + 0.2117 \qquad (33)$$

$$C = \left(\frac{\pi D_i^2 S_a}{8P} + 1.0370\right)^{1/3} + 0.6667 \qquad (34)$$

$$B_o = \frac{FGD_o}{8P} = C^3(C+1)N_a \qquad (35)$$

$$A_o = C^3(C+1) \qquad (36)$$

$$N_a = \frac{B_o}{A_o} \qquad (37)$$

$$C = A_o^{1/4} - 0.234 \qquad (38)$$

$$B_i = \frac{FGD_i}{8P} = C^3(C-1)N_a \qquad (39)$$

$$A_i = C^3(C-1) \qquad (40)$$

$$N_a = \frac{B_i}{A_i} \qquad (41)$$

$$C = A_i^{1/4} + 0.270 \qquad (42)$$

the working load as dictated by the allowable working stress.

Basic Relationships: Certain concepts can be helpful in simplifying spring design before detailed calculations are begun.

As a general rule of good practice, deflection from zero load (free height) to maximum working load should not exceeed 80 per cent of total deflection (to solid height). Deflection beyond this limit reaches that portion of the total deflection range where the coils close unequally, causing unpredictable load conditions and a rapid increase in spring rate. Conversely, the initial deflection to assembled height should not be less than 20 per cent of total deflection to offset the effect of closed end coils.

These characteristics also merit early attention:

1. Minimum practical value of spring index is generally believed to be about 4, although some authorities say 3.
2. For a given coil diameter, load, and spring rate, as the spring index increases
   - Wahl stress-correction factor decreases
   - stress increases
   - deflection per coil increases
   - number of active coils decreases
   - free height decreases
   - wire size decreases
3. For a given coil diameter, a "soft" spring will have a relatively low spring rate, a relatively small wire size, a relatively high spring index, and relatively high stress. For a "stiff" spring, the converse would be true.

Other factors requiring attention before detailed calculations are begun are:

1. Minimum fatigue life in terms of the minimum number of loading cycles the spring is expected to endure without failure.
2. Stress range as defined by the change in stress be-

Table 2—Constants for Calculations Based on Coil OD

C_o	u_o	k_o	r_o	C_o	u_o	k_o	r_o	C_o	u_o	k_o	r_o
4.0000	122.23	193.12	13310	8.7000	1484.1	1768.8	361.92	13.400	5689.8	6324.1	56.265
4.1000	132.70	206.42	11769	8.8000	1538.2	1829.1	344.22	13.500	5801.2	6465.0	54.519
4.2000	143.74	220.37	10445	8.9000	1593.5	1890.7	327.59	13.600	5934.6	6607.9	52.839
4.3000	155.38	235.00	9302.5	9.0000	1650.1	1953.8	311.96	13.700	6069.9	6753.0	51.224
4.4000	167.62	250.32	8312.2	9.1000	1708.1	2018.2	297.24	13.800	6207.4	6900.1	49.671
4.5000	180.48	266.34	7450.6	9.2000	1767.4	2084.0	283.39	13.900	6346.9	7049.5	48.175
4.6000	193.98	283.07	6698.0	9.3000	1828.0	2151.3	270.33	14.000	6488.4	7200.9	46.736
4.7000	208.13	300.54	6038.2	9.4000	1890.0	2220.0	258.01	14.100	6632.1	7354.5	45.350
4.8000	222.95	318.75	5457.8	9.5000	1953.5	2290.1	246.39	14.200	6777.8	7510.3	44.014
4.9000	238.45	337.72	4945.6	9.6000	2018.3	2361.8	235.42	14.300	6925.7	7668.3	42.728
5.0000	254.65	357.46	4492.2	9.7000	2084.5	2434.9	225.06	14.400	7075.7	7828.4	41.488
5.1000	271.56	377.99	4089.6	9.8000	2152.2	2509.5	215.25	14.500	7227.9	7990.8	40.293
5.2000	289.20	399.33	3731.3	9.9000	2221.3	2585.6	205.97	14.600	7382.2	8155.4	39.141
5.3000	307.58	421.48	3411.4	10.000	2291.8	2663.3	197.19	14.700	7538.7	8322.3	38.030
5.4000	326.72	444.46	3125.0	10.100	2363.9	2742.5	188.87	14.800	7697.4	8491.4	36.958
5.5000	346.64	468.29	2868.2	10.200	2437.4	2823.3	180.99	14.900	7858.3	8662.8	35.923
5.6000	367.34	492.99	2637.2	10.300	2512.5	2905.6	173.51	15.000	8021.4	8836.6	34.925
5.7000	388.85	518.56	2429.1	10.400	2589.0	2989.6	166.41	15.100	8186.8	9012.6	33.960
5.8000	411.19	545.02	2241.1	10.500	2667.1	3075.1	159.68	15.200	8354.4	9190.9	33.029
5.9000	434.35	572.39	2070.9	10.600	2746.8	3162.3	153.28	15.300	8524.3	9371.6	32.130
6.0000	458.37	600.69	1916.7	10.700	2828.0	3251.1	147.20	15.400	8696.5	9554.6	31.261
6.1000	483.25	629.92	1776.5	10.800	2910.8	3341.6	141.42	15.500	8871.0	9740.1	30.421
6.2000	509.01	660.11	1648.9	10.900	2995.2	3433.7	135.92	15.600	9047.8	9927.9	29.609
6.3000	535.67	691.26	1532.6	11.000	3081.2	3527.5	130.68	15.700	9226.9	10118	28.824
6.4000	563.24	723.39	1426.4	11.100	3168.9	3623.0	125.70	15.800	9408.4	10311	28.065
6.5000	591.74	756.53	1329.2	11.200	3258.2	3720.3	120.95	15.900	9592.3	10506	27.331
6.6000	621.18	790.68	1240.2	11.300	3349.1	3819.2	116.42	16.000	9778.5	10703	26.620
6.7000	651.58	825.85	1158.5	11.400	3441.8	3919.9	112.10	16.100	9967.1	10903	25.933
6.8000	682.95	862.07	1083.5	11.500	3536.1	4022.4	107.98	16.200	10158	11106	25.267
6.9000	715.30	899.35	1014.4	11.600	3632.1	4126.6	104.05	16.300	10352	11311	24.623
7.0000	748.66	937.70	950.73	11.700	3729.9	4232.7	100.29	16.400	10547	11518	23.999
7.1000	783.04	977.14	891.99	11.800	3829.4	4340.5	96.706	16.500	10746	11728	23.395
7.2000	818.46	1017.7	837.72	11.900	3930.6	4450.2	93.278	16.600	10947	11941	22.810
7.3000	854.92	1059.4	787.52	12.000	4033.6	4561.7	90.001	16.700	11150	12156	22.243
7.4000	892.45	1102.2	741.03	12.100	4138.4	4675.0	86.867	16.800	11356	12373	21.693
7.5000	931.06	1146.1	697.92	12.200	4245.0	4790.2	83.868	16.900	11564	13593	21.161
7.6000	970.76	1191.2	657.90	12.300	4353.4	4907.3	80.997	17.000	11775	12816	20.644
7.7000	1011.6	1237.5	620.72	12.400	4463.6	5026.3	78.248	17.100	11988	13042	20.143
7.8000	1053.5	1285.0	586.12	12.500	4575.7	5147.2	75.614	17.200	12204	13270	19.658
7.9000	1096.6	1333.7	553.90	12.600	4689.6	5270.1	73.091	17.300	12423	13500	19.187
8.0000	1140.8	1383.7	523.87	12.700	4805.4	5394.9	70.672	17.400	12644	13734	18.730
8.1000	1186.2	1434.8	495.85	12.800	4923.1	5521.6	68.352	17.500	12867	13969	18.285
8.2000	1232.8	1487.3	469.67	12.900	5042.7	5650.3	66.127	17.600	13094	14208	17.855
8.3000	1280.6	1541.0	445.21	13.000	5164.3	5781.0	63.991	17.700	13323	14450	17.437
8.4000	1329.6	1595.9	422.31	13.100	5287.7	5913.7	61.941	17.800	13554	14694	17.031
8.5000	1379.9	1652.2	400.87	13.200	5413.1	6048.5	59.973	17.900	13789	14941	16.637
8.6000	1431.4	1709.8	380.78	13.300	5540.5	6185.3	58.082	18.000	14026	15190	16.255

tween zero load and maximum load, or between some intermediate load and maximum.

3. Maximum allowable stress relative to both stress range and fatigue life, and also to static service (relief-valve spring), or dynamic service (engine-valve spring).
4. Material selection as influenced by service conditions such as corrosive environment, stress levels, elevated temperature, shock loading, and fatigue resistance.

• Design Procedures

Basic design equations for round-wire helical compression springs are given in Table 1.

Design Constants: Tables 2, 3, and 4 contain design constants which are functions of the spring index in terms of the OD and ID. These constants are used with the equations in Table 1 to linearize design calculations.

Table 2 is based on the coil OD, and Table 3 on the coil ID. Constants in the u columns of these tables are used for calculating uncorrected stresses while those in the k columns apply to Wahl-corrected stresses. Constants in r columns are used to calculate number of active coils from spring rate.

Table 4 contains values of n_o (OD) and n_i (ID), which are used to calculate deflection per coil.

Values of r_o, Table 2, and r_i, Table 3, are based on a torsional modulus, G = 11,500,000 psi (steel). For other modulus values, corresponding values of r will be directly proportional to the new modulus.

Values of n_o and n_i, Table 4, are also based on G = 11,500,000 psi. However, for other modulus

Table 3—Constants for Calculations Based on Coil ID

C_i	u_i	k_i	r_i	C_i	u_i	k_i	r_i	C_i	u_i	k_i	r_i
2.0000	30.556	48.281	26620	6.7000	880.20	1049.0	469.96	11.400	4103.7	4577.2	66.136
2.1000	34.813	54.153	22978	6.8000	918.44	1092.2	445.47	11.500	4209.6	4691.3	64.000
2.2000	39.440	60.465	19940	6.9000	957.78	1136.4	422.55	11.600	4317.4	4807.3	61.950
2.3000	44.454	67.234	17392	7.0000	998.22	1181.9	401.09	11.700	4427.1	4925.2	59.981
2.4000	49.870	74.475	15239	7.1000	1039.8	1228.6	380.97	11.800	4538.5	5045.0	58.089
2.5000	55.704	82.204	13411	7.2000	1082.5	1276.4	362.10	11.900	4651.8	5166.8	56.272
2.6000	61.971	90.434	11850	7.3000	1126.3	1325.5	344.39	12.000	4767.0	5290.5	54.525
2.7000	68.686	99.182	10511	7.4000	1171.3	1375.8	327.75	12.100	4884.1	5416.1	52.846
2.8000	75.865	108.46	9356.2	7.5000	1217.5	1427.4	312.10	12.200	5003.0	5543.7	51.230
2.9000	83.522	118.29	8356.3	7.6000	1264.9	1480.2	297.37	12.300	5123.9	5673.3	49.676
3.0000	91.673	128.69	7487.0	7.7000	1313.5	1534.3	283.50	12.400	5246.7	5804.9	48.181
3.1000	100.33	139.66	6728.1	7.8000	1363.4	1589.7	270.44	12.500	5371.5	5938.5	46.741
3.2000	109.52	151.22	6063.3	7.9000	1414.4	1646.5	258.11	12.600	5498.2	6074.1	45.355
3.3000	119.24	163.40	5478.8	8.0000	1466.8	1704.5	246.48	12.700	5626.9	6211.8	44.019
3.4000	129.52	176.20	4963.3	8.1000	1520.4	1763.9	235.50	12.800	5757.6	6351.5	42.733
3.5000	140.37	189.64	4507.2	8.2000	1575.3	1824.7	225.13	12.900	5890.3	6493.3	41.493
3.6000	151.81	203.75	4102.3	8.3000	1631.5	1886.8	215.32	13.000	6025.0	6637.2	40.298
3.7000	163.85	218.50	3742.1	8.4000	1689.0	1950.3	206.04	13.100	6161.7	6783.2	39.145
3.8000	176.50	233.95	3420.6	8.5000	1747.8	2015.2	197.25	13.200	6300.5	6931.4	38.034
3.9000	189.79	250.10	3132.0	8.6000	1808.0	2081.5	188.93	13.300	6441.4	7081.6	36.961
4.0000	203.72	266.97	2875.0	8.7000	1869.6	2149.3	181.04	13.400	6584.3	7234.1	35.927
4.1000	218.31	284.57	2643.0	8.8000	1932.6	2218.5	173.56	13.500	6729.4	7388.7	34.928
4.2000	233.58	302.92	2434.2	8.9000	1996.9	2289.2	166.46	13.600	6876.6	7545.5	33.963
4.3000	249.55	322.03	2245.5	9.0000	2062.6	2361.4	159.72	13.700	7025.8	7704.4	33.032
4.4000	266.22	341.92	2074.8	9.1000	2129.8	2435.0	153.32	13.800	7177.3	7865.6	32.132
4.5000	283.61	362.60	1920.0	9.2000	2198.4	2510.2	147.24	13.900	7330.9	8029.0	31.263
4.6000	301.75	384.08	1779.5	9.3000	2268.5	2586.9	141.45	14.000	7486.6	8194.7	30.423
4.7000	320.63	406.39	1651.5	9.4000	2340.1	2665.2	135.95	14.100	7644.6	8362.6	29.611
4.8000	340.29	429.54	1534.9	9.5000	2413.1	2745.0	130.71	14.200	7804.8	8532.8	28.826
4.9000	360.73	453.55	1428.4	9.6000	2487.6	2826.3	125.72	14.300	7967.2	8705.3	28.067
5.0000	381.97	478.42	1331.0	9.7000	2563.7	2909.3	120.97	14.400	8131.8	8880.1	27.333
5.1000	404.03	504.18	1241.8	9.8000	2641.3	2993.8	116.44	14.500	8298.7	9057.2	26.622
5.2000	426.91	530.83	1159.9	9.9000	2720.4	3080.0	112.12	14.600	8467.8	9236.6	25.935
5.3000	450.64	558.40	1084.7	10.000	2801.1	3167.8	108.00	14.700	8639.2	9418.4	25.269
5.4000	475.23	586.91	1015.5	10.100	2883.4	3257.3	104.07	14.800	8812.9	9602.6	24.625
5.5000	500.70	616.35	951.71	10.200	2967.3	3348.4	100.31	14.900	8989.0	9789.1	24.001
5.6000	527.06	646.76	892.87	10.300	3052.8	3441.2	96.724	15.000	9167.3	9978.1	23.397
5.7000	554.33	678.14	838.51	10.400	3139.9	3535.7	93.295	15.100	9348.0	10169	22.811
5.8000	582.51	710.52	788.23	10.500	3228.6	3631.9	90.017	15.200	9531.1	10363	22.244
5.9000	611.64	743.90	741.67	10.600	3319.0	3729.8	86.882	15.300	9761.5	10559	21.695
6.0000	641.71	778.31	698.49	10.700	3411.1	3829.5	83.882	15.400	9904.3	10758	21.162
6.1000	672.76	813.75	658.42	10.800	3504.9	3930.9	81.010	15.500	10095	10959	20.645
6.2000	704.78	850.24	621.18	10.900	3600.3	4034.1	78.260	15.600	10287	11163	20.145
6.3000	737.81	887.80	586.54	11.000	3697.5	4139.1	75.626	15.700	10482	11369	19.659
6.4000	771.85	926.45	554.28	11.100	3796.4	4245.9	73.102	15.800	10680	11578	19.188
6.5000	806.92	966.19	524.22	11.200	3897.1	4354.5	70.682	15.900	10880	11789	18.731
6.6000	843.03	1007.0	496.16	11.300	3999.5	4464.9	68.362	16.000	11082	12003	18.287

values, corresponding values of n_o and n_i will be inversely proportional to the new modulus.

Design Example—Problem Type 1: Design a round-wire, helical compression spring, Fig. 1, to fit into a 2.125 in. diam hole. Ends are to be squared and ground (two dead coils). Working load is 565 lbs at 3.875 in. compressed height. Stresses are to be Wahl-corrected. Working-load stress is to be 80 per cent of the stress at solid height and must not exceed 76,000 psi.

SOLUTION: A coil OD of 2 in. is selected to allow for OD growth when the spring is compressed. Since $S_1/S = 0.8$, from Equation 19, $P = 565/0.8 = 707$ lb. Corresponding allowable solid stress $S_s = 76{,}000/0.8 = 95{,}000$ psi.

From Equation 2 (Wahl-corrected stress),

$$k_o = \frac{S_1 D_o^2}{P_1} = \frac{76{,}000(2)^2}{565} = 538$$

In Table 2, the value of C_o, corresponding to $k_o = 538$, falls between 5.7 and 5.8. By interpolation $C_o = 5.77$.

[Note that a substantially different C_o value would have been obtained if the design were based on uncorrected stress. Then the u_o column would apply. From Table 2, the value of C_o corresponding to $u_o = 538$ is approximately 6.3.]

From Equation 4, wire size $d = 2/5.77 = 0.353$ in. Nearest standard wire size is $d = 0.3625$ in. (3/0 Steel Wire Gage). From Equation 4, the adjusted spring index for this standard wire size is $C_o = 5.53$. From Table 2, $k_o = 475$. The adjusted working stress from Equation 2 is $S_1 = 67{,}000$ psi, which is well within the imposed limit.

Next step is to establish the distance from work-

Table 4—Constants for Coil-Deflection Calculations

C_o	n_o	C_i	n_i	C_o	n_o	C_i	n_i	C_o	n_o	C_i	n_i
4.0000	0.000075130	2.0000	0.000037565	8.7000	0.0027630	6.7000	0.0021278	13.400	0.017773	11.400	0.015120
4.1000	0.000084969	2.1000	0.000043521	8.8000	0.0029051	6.8000	0.0022448	13.500	0.018342	11.500	0.015625
4.2000	0.000095740	2.2000	0.000050149	8.9000	0.0030526	6.9000	0.0023666	13.600	0.018925	11.600	0.016142
4.3000	0.00010750	2.3000	0.000057499	9.0000	0.0032056	7.0000	0.0024932	13.700	0.019522	11.700	0.016672
4.4000	0.00012030	2.4000	0.000065621	9.1000	0.0033643	7.1000	0.0026249	13.800	0.020133	11.800	0.017215
4.5000	0.00013422	2.5000	0.000074565	9.2000	0.0035288	7.2000	0.0027616	13.900	0.020758	11.900	0.017771
4.6000	0.00014930	2.6000	0.000084387	9.3000	0.0036992	7.3000	0.0029037	14.000	0.021397	12.000	0.018340
4.7000	0.00016561	2.7000	0.000095140	9.4000	0.0038758	7.4000	0.0030511	14.100	0.022051	12.100	0.018923
4.8000	0.00018322	2.8000	0.00010688	9.5000	0.0040586	7.5000	0.0032041	14.200	0.022720	12.200	0.019520
4.9000	0.00020220	2.9000	0.00011967	9.6000	0.0042477	7.6000	0.0033628	14.300	0.023404	12.300	0.020130
5.0000	0.00022261	3.0000	0.00013357	9.7000	0.0044435	7.7000	0.0035273	14.400	0.024103	12.400	0.020755
5.1000	0.00024452	3.1000	0.00014863	9.8000	0.0046459	7.8000	0.0036977	14.500	0.024818	12.500	0.021395
5.2000	0.00026801	3.2000	0.00016493	9.9000	0.0048551	7.9000	0.0038743	14.600	0.025548	12.600	0.022049
5.3000	0.00029314	3.3000	0.00018252	10.000	0.0050713	8.0000	0.0040570	14.700	0.026295	12.700	0.022717
5.4000	0.00032000	3.4000	0.00020148	10.100	0.0052947	8.1000	0.0042462	14.800	0.027058	12.800	0.023401
5.5000	0.00034865	3.5000	0.00022187	10.200	0.0055253	8.2000	0.0044419	14.900	0.027837	12.900	0.024101
5.6000	0.00037919	3.6000	0.00024376	10.300	0.0057634	8.3000	0.0046443	15.000	0.028633	13.000	0.024815
5.7000	0.00041168	3.7000	0.00026723	10.400	0.0060091	8.4000	0.0048535	15.100	0.029446	13.100	0.025546
5.8000	0.00044621	3.8000	0.00029235	10.500	0.0062626	8.5000	0.0050697	15.200	0.030276	13.200	0.026292
5.9000	0.00048287	3.9000	0.00031919	10.600	0.0065240	8.6000	0.0052930	15.300	0.031124	13.300	0.027055
6.0000	0.00052174	4.0000	0.00034783	10.700	0.0067935	8.7000	0.0055237	15.400	0.031989	13.400	0.027835
6.1000	0.00056290	4.1000	0.00037834	10.800	0.0070712	8.8000	0.0057617	15.500	0.032872	13.500	0.028631
6.2000	0.00060645	4.2000	0.00041082	10.900	0.0073574	8.9000	0.0060074	15.600	0.033773	13.600	0.029444
6.3000	0.00065247	4.3000	0.00044534	11.000	0.0076522	9.0000	0.0062609	15.700	0.034693	13.700	0.030274
6.4000	0.00070106	4.4000	0.00048198	11.100	0.0079557	9.1000	0.0065223	15.800	0.035632	13.800	0.031121
6.5000	0.00075230	4.5000	0.00052083	11.200	0.0082682	9.2000	0.0067917	15.900	0.036589	13.900	0.031986
6.6000	0.00080631	4.6000	0.00056197	11.300	0.0085898	9.3000	0.0070693	16.000	0.037565	14.000	0.032870
6.7000	0.00086316	4.7000	0.00060550	11.400	0.0089207	9.4000	0.0073556	16.100	0.038561	14.100	0.033771
6.8000	0.00092296	4.8000	0.00065150	11.500	0.0092610	9.5000	0.0076504	16.200	0.039577	14.200	0.034691
6.9000	0.00098582	4.9000	0.00070007	11.600	0.0096110	9.6000	0.0079539	16.300	0.040612	14.300	0.035629
7.0000	0.0010518	5.0000	0.00075130	11.700	0.0099708	9.7000	0.0082664	16.400	0.041668	14.400	0.036586
7.1000	0.0011211	5.1000	0.00080529	11.800	0.010341	9.8000	0.0085879	16.500	0.042744	14.500	0.037563
7.2000	0.0011937	5.2000	0.00086213	11.900	0.010721	9.9000	0.0089188	16.600	0.043840	14.600	0.038558
7.3000	0.0012698	5.3000	0.00092191	12.000	0.011111	10.000	0.0092591	16.700	0.044958	14.700	0.039574
7.4000	0.0013495	5.4000	0.00098475	12.100	0.011512	10.100	0.0096091	16.800	0.046097	14.800	0.040609
7.5000	0.0014328	5.5000	0.0010507	12.200	0.011924	10.200	0.0099689	16.900	0.047257	14.900	0.041665
7.6000	0.0015200	5.6000	0.0011200	12.300	0.012346	10.300	0.010339	17.000	0.048440	15.000	0.042741
7.7000	0.0016110	5.7000	0.0011928	12.400	0.012780	10.400	0.010719	17.100	0.049644	15.100	0.043838
7.8000	0.0017061	5.8000	0.0012687	12.500	0.013225	10.500	0.011109	17.200	0.050870	15.200	0.044955
7.9000	0.0018054	5.9000	0.0013483	12.600	0.013682	10.600	0.011510	17.300	0.052120	15.300	0.046094
8.0000	0.0019089	6.0000	0.0014317	12.700	0.014150	10.700	0.011922	17.400	0.053392	15.400	0.047255
8.1000	0.0020168	6.1000	0.0015188	12.800	0.014630	10.800	0.012344	17.500	0.054687	15.500	0.048436
8.2000	0.0021291	6.2000	0.0016098	12.900	0.015122	10.900	0.012778	17.600	0.056005	15.600	0.049641
8.3000	0.0022462	6.3000	0.0017049	13.000	0.015627	11.000	0.013223	17.700	0.057348	15.700	0.050868
8.4000	0.0023679	6.4000	0.0018041	13.100	0.016144	11.100	0.013680	17.800	0.058714	15.800	0.052117
8.5000	0.0024946	6.5000	0.0019076	13.200	0.016674	11.200	0.014148	17.900	0.060104	15.900	0.053389
8.6000	0.0026262	6.6000	0.0020155	13.300	0.017217	11.300	0.014628	18.000	0.061519	16.000	0.054684

ing height to solid height at some suitable value, say $F_2 = 0.375$ in. Since working stress is to be 80 per cent of total stress, working load deflection must be 80 per cent of total deflection. Therefore, $F = 0.375/0.2 = 1.875$ in. From Equation 25, spring rate (gradient) $R = 707/1.875 = 377$ lb/in.

This value can be readily checked. From Equation 14, $F_1 = 1.875\text{-}0.375 = 1.5$ in. Then, $R = 565/1.5 = 377$ lb/in. which verifies the previous result.

The number of active coils is obtained from Equation 9. From Table 2 at $C_o = 5.53$, corresponding value of r_o is, by interpolation, 2799. Use $r_o = 2800$. From Equation 9, $N_a = 2(2800)/377 = 14.85$. Since the ends are squared and ground, total number of coils $N = 16.85$ and, from Equation 21, $h = 0.3625\ (16.85) = 6.10$ in.

The free height, from Equation 23, is $H = 6.10 + 1.875 = 7.975$ in. Thus the lineal space required for this spring is approximately 8 in. and must be allowed for in design.

Design Example—Problem Type 2: Design a round-wire, helical, compression spring, Fig. 1, to fit over a 1.5 in. diam pin. Ends are to be squared and ground (two dead coils). The working load is to be 93 lb at 2 in. deflection. The Wahl-corrected working-load stress is not to exceed 95,000 psi and is to be 85 per cent of solid-height stress.

SOLUTION: Establish coil ID at 1.5625 in. Since deflection and load are given, spring rate is, from Equation 25, $R = 93/2 = 46.5$ lb/in.

From Equation 2,

$$k_i = \frac{S_1 D_i^2}{P_1} = \frac{95{,}000\,(1.5625)^2}{93} = 2490$$

From Table 3 at $k_i = 2490$, the corresponding value of C_i is between 9.1 and 9.2. By interpolation, $C_i = 9.17$, and $C = C_i + 1 = 10.17$.

From Equation 5, $d = 1.5625/9.17 = 0.1704$. Nearest standard wire size is $d = 0.170$ (7½ Steel Wire Gage).

From Table 3 at $C_i = 9.17$, $r_i = 147.8$, and from Equation 9, $N_a = 1.5625\ (147.8)/46.5 = 4.97$.

Since $S_1/S = 0.85$, from Equation 13, $F = 2/0.85 = 2.35$ in. For squared and ground ends, total number of coils $N = 6.97$. From Equation 21, $h = 0.170\ (6.97) = 1.183$ in. and from Equation 23, $H = 1.183 + 2.35 = 3.533$ in.

To check the calculations, Equation 2 may be used. From Equation 20, $P = 46.5\ (2.35) = 109.5$ lb. Then, from Equation 2,

$$S = \frac{109.5}{(1.5625)^2}\ (2490) = 111{,}500 \text{ psi}$$

and $S_1 = 0.85\ (111{,}500) = 94{,}800$ psi, which is within the required limit. Here, again, the lineal space required to store the desired energy at a given stress level has been determined.

Design Example—Problem Type 3: Design a

Table 5—Working Stresses

Material* (ASTM Spec. No.)	Allowable Working Stress† (psi) Severe Service	Average Service	Light Service	Solid-Height Stress Limit‡ (psi)
$d = 0.020$ to 0.030 in.				
A227	80,000	106,000	120,000	135,000
A228	99,000	132,000	149,000	165,000
A229	84,000	110,000	125,000	140,000
A231	90,000	120,000	135,000	150,000
A313	76,000	102,000	115,000	127,000
A401	108,000	144,000	162,000	180,000
$d = 0.031$ to 0.040 in.				
A227	77,000	103,000	115,000	128,000
A228	94,000	126,000	142,000	158,000
A229	80,000	105,000	118,000	132,000
A231	86,000	115,000	130,000	145,000
A313	74,000	98,000	111,000	123,000
A401	103,000	138,000	156,000	174,000
$d = 0.041$ to 0.050 in.				
A227	74,000	98,000	111,000	124,000
A228	91,000	122,000	136,000	152,000
A229	77,000	101,000	113,000	126,000
A231	83,000	111,000	125,000	139,000
A313	72,000	95,000	107,000	118,000
A401	99,500	133,000	150,000	167,000
$d = 0.051$ to 0.060 in.				
A227	72,000	95,000	107,000	120,000
A228	89,000	119,000	132,000	148,000
A229	74,000	97,000	109,000	120,000
A231	82,000	108,000	122,000	135,000
A313	70,000	93,000	105,000	116,000
A401	98,500	129,500	146,500	162,000
$d = 0.061$ to 0.070 in.				
A227	69,000	92,000	104,000	116,000
A228	87,000	116,000	128,000	144,000
A229	71,000	95,000	107,000	118,000
A231	79,000	105,000	119,000	131,000
A313	68,000	91,000	103,000	114,000
A401	94,000	126,000	143,000	157,000

Standard

Cost index values are based on a comparison of material cost with ASTM A227 which is the least expensive material listed here. These values are intended only to give a rough indication of relative cost levels for the various spring materials.

ASTM A227—Hard-Drawn Carbon-Steel Spring Wire

Low-cost material for average stress application where precision accuracy of wire diameter, spring diameter, and loads is not essential. This material can be readily electroplated. It should not be used in applications where long life is required.

Cost Index: 1.0

Mechanical Properties: Young's modulus $E = 30{,}000{,}000$ psi. Torsional modulus $G = 11{,}500{,}000$ psi.
Maximum operating temperature (4 per cent relaxation in 72 hr) is 300 F at 7000 psi, 200 F at 55,000 psi.
Density = 0.284 lb/cu in.
Steel Wire Gage (AISI) sizes should be used.

ASTM A228—Carbon-Steel Music Spring Wire

Highest-quality, cold-drawn, high-carbon steel wire in the ferrous group. It has exceptionally high tensile strength and uniform temper. It is recommended for small springs which are subjected to high stresses. Music wire is not furnished in any sections other than round.

Cost Index: 3.5

Mechanical Properties: Young's modulus $E = 30{,}000{,}000$ psi. For $d \leqq 0.100$ in., torsional modulus $G = 12{,}000{,}000$ psi; for $d > 0.100$ in., $G = 11{,}750{,}000$ psi.
Maximum operating temperature (4 per cent relaxation

for Round-Wire Compression Springs

Material* (ASTM Spec. No.)	Allowable Working Stress† (psi) Severe Service	Average Service	Light Service	Solid-Height Stress Limit‡ (psi)
$d = 0.071$ to 0.080 in.				
A227	67,000	90,000	102,000	113,000
A228	85,000	113,000	126,000	140,000
A229	69,000	92,000	104,000	115,000
A231	77,000	103,000	116,000	128,000
A313	67,000	89,000	100,000	111,000
A401	92,500	123,500	139,000	153,500
$d = 0.081$ to 0.090 in.				
A227	66,000	88,000	100,000	111,000
A228	83,000	110,000	123,000	138,000
A229	68,000	90,000	102,000	113,000
A231	76,000	100,000	115,000	127,000
A313	65,000	87,000	98,000	108,000
A401	91,000	120,000	138,000	152,000
$d = 0.091$ to 0.100 in.				
A227	64,500	86,500	98,500	109,000
A228	80,000	109,000	121,000	135,000
A229	67,000	89,000	100,000	111,000
A231	74,000	98,000	112,000	125,000
A313	63,000	85,000	96,000	106,000
A401	88,500	117,500	134,500	150,000
$d = 0.101$ to 0.120 in.				
A227	62,500	84,500	95,000	105,000
A228	78,000	105,000	108,000	130,000
A229	64,000	85,000	96,000	108,000
A231	72,000	96,000	108,000	122,000
A313	60,000	82,000	91,000	102,000
A401	86,500	115,000	129,000	146,000
$d = 0.121$ to 0.140 in.				
A227	61,000	82,000	92,000	102,000
A229	62,000	83,000	94,000	105,000
A231	70,000	93,000	105,000	118,000
A313	57,000	78,000	87,000	97,000
A401	84,000	111,500	126,000	141,500
$d = 0.141$ to 0.160 in.				
A227	59,000	80,000	90,000	99,000
A229	60,000	80,000	91,000	103,000
A231	65,000	91,000	103,000	115,000
A313	55,000	74,000	83,000	93,000
A401	81,500	109,000	123,500	138,000
$d = 0.161$ to 0.190 in.				
A227	57,000	77,000	87,000	96,000
A229	57,000	77,000	87,000	97,000
A231	66,000	88,000	99,000	110,000
A313	52,000	70,000	78,000	87,000
A401	79,000	105,500	119,000	132,000
$d = 0.191$ to 0.250 in.				
A227	55,000	74,000	84,000	93,000
A229	53,000	73,000	81,000	90,000
A231	62,000	83,000	93,000	103,000
A313	46,000	62,000	69,000	78,000
A401	74,000	99,000	111,000	123,000
$d = 0.251$ to 0.313 in.				
A227	52,000	71,000	77,000	86,000
A229	51,000	70,000	76,000	85,000
A231	59,000	81,000	91,000	101,000
A313	42,000	56,000	63,000	72,000
A401	71,000	97,000	109,000	121,000

*See accompanying section on *Standard Spring Materials* for description and properties data.

†Based on a stress range of zero to maximum (zero load to maximum working load), and on the number of loading cycles the spring is expected to endure: Severe service = 10,000,000 cycles; average service = 100,000 cycles; light service = 10,000 cycles.

‡Minimum torsional elastic limit.

Spring Materials

in 72 hr) is 300 F at 2000 psi, 200 F at 100,000 psi.
Density = 0.284 lb/cu in.
Music-wire gage sizes should be used.

ASTM A229—Oil-Tempered Carbon-Steel Spring Wire

General-purpose spring steel of fairly uniform quality and temper. Because of its surface condition (slight scale), this material is recommended for use where stress requirements are not too severe, the spring is not subjected to shock or impact loading, and spring index $C \geq 5$.

Cost Index: 1.5

Mechanical Properties: Young's modulus $E = 28{,}500{,}000$ psi. Torsional modulus $G = 11{,}200{,}000$ psi.
Maximum operating temperature (4 per cent relaxation in 72 hr) is 300 F at 40,000 psi, 200 F at 100,000 psi.
Density = 0.284 lb/cu in.
Steel Wire Gage (AISI) sizes should be used.

ASTM A231—Chrome-Vanadium Steel Spring Wire

High-quality spring steel which will withstand higher stresses than oil-tempered carbon-steel wire, but not as high as music wire. This material is recommended for springs which are subjected to shock or impact loading, and to a large number of loading cycles.

Cost Index: 4.0

Mechanical Properties: Young's modulus $E = 29{,}500{,}000$ psi. Torsional modulus $G = 11{,}200{,}000$ psi.
Maximum operating temperature (4 per cent relaxation in 72 hr) is 400 F at 35,000 psi, 300 F at 100,000 psi, 200 F at 135,000 psi.
Density = 0.284 lb/cu in.
Steel Wire Gage (AISI) sizes should be used.

ASTM A313—Stainless-Steel Spring Wire (Type 302)

General-purpose, corrosion-resisting material. Its spring properties are developed only by cold working. This material is slightly magnetic in its spring temper, has low creep, and resists relaxation at elevated temperatures.

Cost Index: 8.5

Mechanical Properties: Young's modulus $E = 28{,}000{,}000$ psi. Torsional modulus $G = 10{,}000{,}000$ psi.
Maximum operating temperature (4 per cent relaxation in 72 hr) is 600 F at 20,000 psi, 500 F at 96,000 psi, 400 F at 108,000 psi, 300 F at 135,000 psi.
Density = 0.288 lb/cu in.
Steel Wire Gage (AISI) sizes should be used.

ASTM A401—Chrome-Silicon Steel Spring Wire

High-quality spring steel which is especially suited for highly stressed springs subjected to shock or impact loading. It also may be used at moderate elevated temperatures. It may be obtained in the oil-tempered condition, but is most often coiled in the annealed state and then heat treated to suitable hardnesses.

Cost Index: 4.0

Mechanical Properties: Young's modulus $E = 29{,}500{,}000$ psi. Torsional modulus $G = 11{,}200{,}000$ psi.
Maximum operating temperature (4 per cent relaxation in 72 hr) is 400 F at 4000 psi, 300 F at 50,000 psi, 200 F at 132,000 psi.
Density = 0.284 lb/cu in.
Steel Wire Gage (AISI) sizes should be used.

round-wire, helical compression spring, Fig. 1, to fit inside a 0.875 in. diam hole. Ends are to be squared and ground. Working load is 8 lb at a 1 in. compressed height. Free height is to be 2.75 in. Stresses are to be uncorrected for shear load and coil curvature. Material is stainless steel for temperature and corrosion resistance. Working-load deflection is to be 80 per cent of total deflection.

SOLUTION: Choose 0.750 in. as the coil OD. Since the material is stainless steel, G = 10,000,000 psi (Table 5). From Equation 26, $F_1 = 2.75 - 1 = 1.75$ in., and from Equation 13, $F = 1.75/0.8 = 2.1875$ in. Then, from Equation 22, $h = 2.75 - 2.1875 = 0.5625$ in. Also, from Equation 19, $P = 8/0.8 = 10$ lb, and from Equation 25, $R = 10/2.1875 = 4.57$ lb/in.

The required number of active coils and the spring index must be determined by successive approximation. In Equation 27, let $y_o = h/D_o = 0.5625/0.750 = 0.750$. Object now is to make the right-hand side of this expression equal to the same value.

As a starting point, let $C_o = 11$. From Table 4, $n_o = 0.00765$ and from Equation 29,

$$n_o N_a = \frac{2.1875(0.750)}{10} = 0.164$$

Let $z_o = n_o N_a$, and adjust z_o for stainless steel. Since $G = 11.5 \times 10^6$ psi for carbon steel,

$$z_o = 0.164 \frac{10 \times 10^6}{11.5 \times 10^6} = 0.1425$$

Then, $N_{a4} = z_o/n_{o4} = 0.1425/0.00765 = 18.65$ and

$$y_{o4} = \frac{N_{a4} + 2}{C_{o4}} = \frac{20.65}{11} = 1.88$$

Compare y_{o4} with y_o. If the values are substantially different, the following procedure should be used. Let $t_{o4} = y_{o4}/y_o = 1.88/0.750 = 2.51$. Then, $n_{o3} = t_{o4}\, n_{o4} = 2.51\ (0.00765) = 0.0192$ and $N_{a3} = z_o/n_{o3} = 0.1425/0.0192 = 7.43$. From Table 4 at $n_{o3} = 0.0192$, $C_{o3} = 13.65$ and

$$y_{o3} = \frac{N_{a3} + 2}{C_{o3}} = \frac{9.43}{13.65} = 0.690$$

which is less than y_o. Repeating the previous steps, $t_{o3} = 0.690/0.750 = 0.920$, $n_{o2} = 0.920\ (0.0192) = 0.01765$, and $N_{a2} = 0.1425/0.01765 = 8.07$. From Table 4, $C_{o2} = 13.4$, and $y_{o2} = 10.07/13.4 = 0.752$.

Repeating the procedure again, $t_{o2} = 1.01$, $n_{o1} = 0.0177$, $N_{a1} = 8.04$, $C_{o1} = 13.4$, and $y_{o1} = 0.750 = y_o$.

Thus, for this design, $N_a = 8.04$, and total number of coils $N = 10.04$. Index $C = C_o - 1 = 12.4$.

From Equation 11, $N_a = 0.750/[0.01777\ (11.5/10)\ (4.57)] = 8.04$, and from Equation 9, $N_a = 0.750\ (56.26)\ (10/11.5)/4.57 = 8.04$, which checks out the previous calculations. Note that both of these calculations include a modulus adjustment.

From Equation 4, $d = 0.750/13.4 = 0.0559$ in. Nearest standard half-gage wire size is $d = 0.058$ in. From Equation 4, adjusted spring index $C_o = (0.750/0.058) = 12.92$. From Table 2, at this adjusted value of C_o, $r_o = 65.7$. From Equation 9,

$$N_a = \frac{0.750(65.7)}{4.57} \frac{10 \times 10^6}{11.5 \times 10^6} = 9.36$$

and adjusted total number of coils is $N = 11.36$. From Equation 21, $h = 0.058\ (11.36) = 0.657$ in., and from Equation 17, $F = 2.75 - 0.657 = 2.093$ in.

Solid load is, by Equation 20, $P = 4.57\ (2.093) = 9.55$ lb.

From Table 2 at $C_o = 12.92$, $u_o = 5066$. From Equation 1, uncorrected solid stress $S = 9.55\ (5066)/$

Table 6—Allowable-Stress Calculations

C_o	d	S_1 (Calculated)	S_a (Table 5)
5	0.300	66,500	91,000
6	0.250	112,500	93,000
5.5	0.273	87,500	91,000
5.6	0.268	91,700	91,000

Slide-Rule Procedures

Procedures given here apply to calculations based on coil OD. Quantities in brackets indicate corresponding parameters when calculations are based on coil ID.

Wire Size

1. Find $D_o^2[D_i^2]$, using C and D-scales.
2. Set hairline to $D_o^2[D_i^2]$ on D-scale.
3. Draw load P on C-scale under hairline.
4. Opposite stress limit S_a on C-scale, read number on D-scale.
5. Locate this number in either the $u_o[u_i]$ column (uncorrected stress) or the $k_o[k_i]$ column (Wahl-corrected stress) of Table 2 [Table 3]. Read corresponding value of $C_o[C_i]$. Note that the value of $C_o[C_i]$ is different for the same value of $u_o[u_i]$ and $k_o[k_i]$.
6. Set hairline to $D_o[D_i]$ on D-scale.
7. Draw $C_o[C_i]$ on C-scale under hairline.
8. Opposite index of C-scale read wire-size d on D-scale.

Number of Active Coils

1. Find value of $r_o[r_i]$ in Table 2 [Table 3] corresponding to $C_o[C_i]$ value used in wire-size calculations.
2. Set hairline to $D_o[D_i]$ on D-scale.
3. Draw spring rate R, on C-scale, under hairline.
4. Opposite $r_o[r_i]$ on C-scale, read number of active coils N_a on D-scale.

Deflection Per Coil

1. Find value of $n_o[n_i]$ in Table 4, corresponding to $C_o[C_i]$ value used in wire-size calculations.
2. Set hairline to load P on D-scale.
3. Draw $D_o[D_i]$ on C-scale under hairline.
4. Opposite $n_o[n_i]$ on C-scale, read deflection per coil f on D-scale.

Electronic-Computer Procedures

The following equations and procedures were developed especially for use with electronic digital computers. They permit spring design calculations to be made in "one pass" through any electronic digital computer when the initial design parameters are judiciously selected.

The special computer expressions are Equations 31 through 42, Table 1.

Spring index C, based on coil OD, is given by Equation 31 for Wahl-corrected stress and by Equation 32 for uncorrected stress. For calculations based on coil ID, Equations 33 (Wahl-corrected) and 34 (uncorrected) should be used.

Equations 35 through 38 are used for type 3 spring-design problems where solution is based on coil OD. Here a procedure of successive approximation is used, starting with an assumed value of A_o and repeating calculations until

$$\frac{N_a + 2}{C + 1} = \frac{h}{D_o}$$

For solution of type 3 problems based on coil ID, Equations 39 through 42 apply. Here again, successive approximation is used, starting with an assumed value of A_i and repeating calculations until

$$\frac{N_a + 2}{C - 1} = \frac{h}{D_i}$$

For calculations of this type, satisfactory results have been obtained by using a computer program with four successive approximations built into it.

Solution Example—Problem Type 2: For the type 2 problem outlined in the text of the article, initial data are: $D_i = 1.5625$ in., $S_s = 95{,}000$ psi (Wahl-corrected), and $P = 93$ lb. From Equation 33,

$$C = \left(\frac{3.1416(1.5625)^2(95{,}000)}{8(93)} + 3.8333 \right)^{1/4} + 0.2117 = 10.14$$

From Equation 5 then, $d = 1.5625/9.14 = 0.171$ in.

Solution Example—Problem Type 3: For the type 3 problem outlined in the text, $F = 2.1875$ in., $G = 10 \times 10^6$ psi, $D_o = 0.750$ in., $P = 10$ lb, and $h = 0.5625$ in.

Let $y_o = h/D_o = 0.5625/0.750 = 0.750$.

From Equation 35,

$$B_o = \frac{2.1875(10)(10)^6(0.750)}{8(10)} = 205{,}000$$

As a starting point, begin with $A_{o4} = 11{,}000$ for $C = 10$ (Equation 36). From Equation 37, $N_{o4} = 205{,}000/11{,}000 = 18.65$, and from Equation 38,

$$C_4 = (11{,}000)^{1/4} - 0.234 = 9.986$$

Then,

$$y_4 = \frac{N_{o4} + 2}{C_4 + 1} = \frac{20.65}{10.986} = 1.882$$

which is more than double the design goal, y_o.

Let $z_4 = y_4/y_o = 1.882/0.750 = 2.51$. For the second approximation, use $A_3 = z_4 A_4 = 2.51\ (11{,}000) = 27{,}600$. Then

$$N_{a3} = \frac{205{,}000}{27{,}600} = 7.43$$

$$C_3 = (27{,}600)^{1/4} - 0.234 = 12.656$$

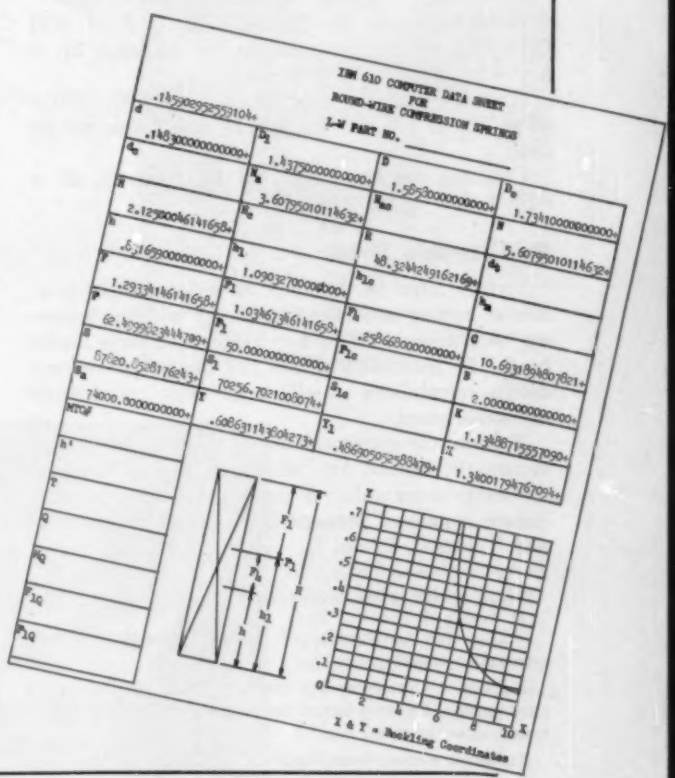
$$y_3 = \frac{9.43}{13.65} = 0.691$$

$$z_3 = \frac{0.691}{0.750} = 0.922$$

For the third approximation, $A_2 = 0.922\ (27{,}600) = 25{,}400$. Repeating the process, $N_{a2} = 8.05$, $C_2 = 12.39$, and $y_2 = 0.752$. This value of y_2 is close enough to the goal, $y_o = 0.750$. Thus, final design solution is: Spring index $C = 12.4$; number of active coils $N_a = 8.05$; and total number of coils $N = 10.05$.

Accuracy of Results: The computer solutions to these problems are not exact because the special equations have a "built-in" error. However, the order of inaccuracy accruing from this error is less than 1 per cent. Since the calculated wire size must be adjusted to the nearest standard size, this small error usually can be ignored.

In practice, the computer program for spring design calculations is set up to read out wire size first, using the special equations developed for this purpose. At this point, the operation is stopped, and wire size is adjusted to the nearest standard dimension. Then the balance of the design calculations are completed using the "standard" equations with the adjusted wire size.



$(0.750)^3 = 86{,}000$ psi.

Corresponding working-load stress is $S_1 = 8(5066)/(0.750)^3 = 72{,}000$ psi.

Checking total deflection by Equations 18 and 12,

$$f = \frac{9.55(0.0152)}{0.750}\,\frac{11.5 \times 10^6}{10 \times 10^6} = 0.223 \text{ in.}$$

$$F = 0.223(9.36) = 2.09 \text{ in.}$$

Checking free height by Equation 23, $H = 0.657 + 2.09 = 2.747$ in.

Design Example—Problem Type 4: Design a round-wire helical compression spring, Fig. 1, with a coil OD of 2.1875 in. and a free height of 16.02 in. Working load is 333 lb. The working-load stress is to be 60 per cent of solid-height stress, which is not to exceed 115,000 psi, Wahl-corrected. Ends are squared and ground.

SOLUTION: The proportional stress requirement gives $S_1 = 115{,}000\ (0.6) = 69{,}000$ psi. From Equation 2,

$$k_o = \frac{69{,}000(2.187)^2}{333} = 990$$

From Table 2, $C_o = 7.13$, and from Equation 4, $d = 2.187/7.13 = 0.307$ in.

From Equation 19, $P = 333/0.6 = 555$ lb. From Table 4 at $C_o = 7.13$, $n_o = 0.001143$, and from Equation 18, $f = 555\ (0.001143)/2.187 = 0.290$ in. From Equation 10,

$$N_a = \frac{16.02 - 0.614}{0.307 + 0\ 290} = 25.8$$

Total deflection, by Equation 12, is $F = 0.29\ (25.8) = 7.49$ in. Solid height, by Equation 21, is $h = 0.307\ (25.8 + 2) = 8.54$ in.

From Equation 2, solid stress $S = 555\ (990)/(2.187)^2 = 115{,}000$ psi which equals the pre-set limit.

Checking the free height by Equation 23, $H = 8.54 + 7.49 = 16.03$ in.

● Allowable Stress

Springs must be designed to perform their function of storing and releasing energy without becoming overstressed. When free height and some loaded height in combination, are not design parameters, design calculations usually begin with an assumed allowable stress.

To take the guesswork out of such assumptions, a systematic, method for "zeroing-in" on an optimum allowable-stress value is presented here. This procedure involves Equations 1, 2, 4, and 5 (Table 1) and Tables 2, 3, and 5.

Steps of the calculation procedure are:

1. Determine the number of loading cycles the spring is expected to endure.

2. Select a suitable spring material, based on the service environment, for such factors as corrosion, elevated temperature, fatigue resistance, etc.

3. Calculate stress from Equation 1 or 2, using Table 2 or 3 and beginning with $C_o = 5$ or $C_i = 3$.

4. Calculate corresponding wire size for a given coil diameter, D_o or D_i, from Equation 4 or 5.

5. Compare calculated stress with the allowable stress given in Table 5 for the calculated wire size and the selected material. If the calculated stress is too large, calculate the maximum allowable load, or the required coil diameter, D_o or D_i, for the allowable stress, Table 5, using Equation 1 or 2. If the calculated stress is less than the allowable stress, choose a larger value for C_o or C_i, and repeat the previous calculations and comparison. If this stress is too high, choose a C_o or C_i value midway between the first two and repeat the calculations and comparison. Continue this systematic zeroing-in process until the calculated stress is close enough to the allowable stress in Table 5 for the standard wire size nearest the final calculated wire size.

6. Calculate adjusted value of C_o or C_i for the standard wire size from Equation 4 or 5.

7. Find the corresponding value of u or k in Table 2 or 3 and calculate adjusted stress from Equation 1 or 2.

When the optimum working stress and wire size for the given load and coil diameter are determined, the balance of the design calculations can be completed.

Design Example—Allowable Stress: Determine the optimum allowable stress and wire size for a round-wire, helical compression spring, with a coil OD of 1.5 in. Maximum working load is 420 lb. At this load, the spring deflects 2.8 in. from free height. Stresses are to be Wahl-corrected. Material is chrome-vanadium steel. Maximum number of loading cycles is 10,000.

SOLUTION: From Equation 2, beginning with $C_o = 5$ for which $k_o = 357$, $S_1 = 66{,}500$ psi. From Equation 4, $d = 0.300$ in.

From Table 5, the allowable stress for chrome-vanadium steel wire of this size is 91,000 psi. Thus, calculated stress is low.

Repeating calculations for $C_o = 6$, $S_1 = 112{,}000$ psi and $d = 0.250$ in. Based on Table 5, this calculated stress is too high.

Next, try $C_o = 5.5$ which gives $S_1 = 87{,}500$ psi and $d = 0.273$ in. From Table 5, $S_a = 91{,}000$ psi. Although the calculated stress is low, $d = 0.273$ is a standard wire size. Thus, this solution could be close enough. However, a check of the next smaller standard wire size, $d = 0.268$ in., is warranted.

From Equation 4, $C_o = 5.6$, which gives (Table 2) $k_o = 492$. From Equation 2, $S_1 = 91{,}700$ psi. A check of Table 5 shows this calculated stress is satisfactory. Thus, for the given load and coil OD, the optimum working stress and wire size have been determined. A suggested form for tabulating these stress calculations is shown in Table 6.

Calculation of the remaining design details may be readily completed.

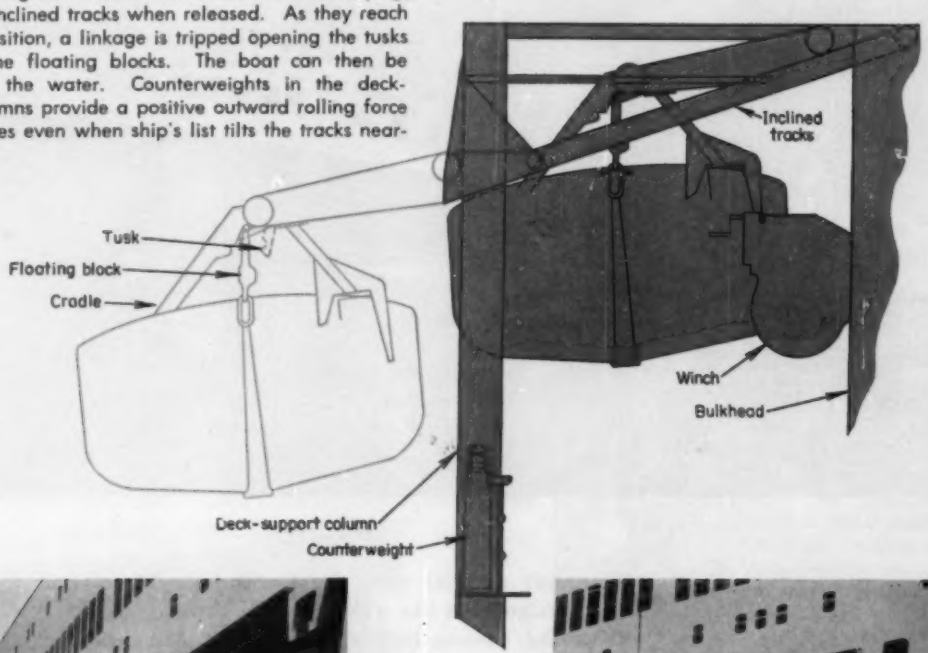
From Equation 25, $R = 150$ lb/in., and from Equation 9, $N_a = 26.37$. Thus, $N = 28.37$. From Equation 21, $h = 7.6$ in., and from Equation 13, $F = 3.5$ in. Then, from Equation 23, $H = 11.1$ in.

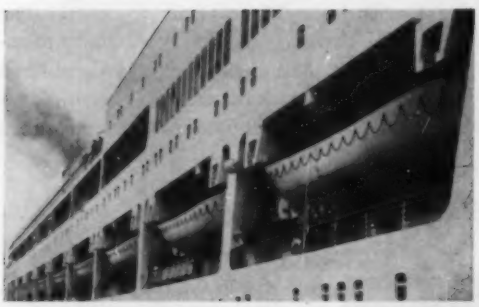
From Equation 20, $P = 525$ lb, and, finally, from Equation 2, $S = 114{,}600$ psi. Checking total deflection by Equation 29, $F = 3.5$ in. which agrees with the previous results.

Between-Decks Davits Launch Lifeboats by Gravity

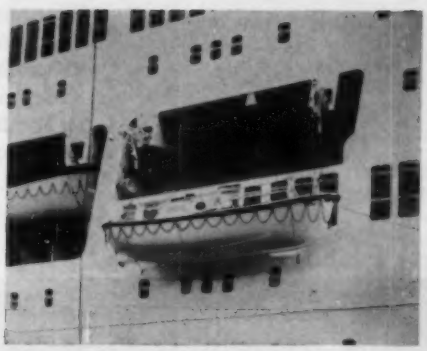
NEITHER power failure nor list keeps gravity-operated lifeboat davits from performing properly on the Canberra. They are designed to overcome as much as a 25-degree adverse list in lowering lifeboats from the side of the ship. The new davits are the result of combining two previous designs—one for between-decks mounting of lifeboat davits, and the other for a gravity-launching mechanism.

CRADLES, designed to hold the lifeboat from swaying, roll out on inclined tracks when released. As they reach outboard position, a linkage is tripped opening the tusks that hold the floating blocks. The boat can then be lowered to the water. Counterweights in the deck-support columns provide a positive outward rolling force on the cradles even when ship's list tilts the tracks nearly level.

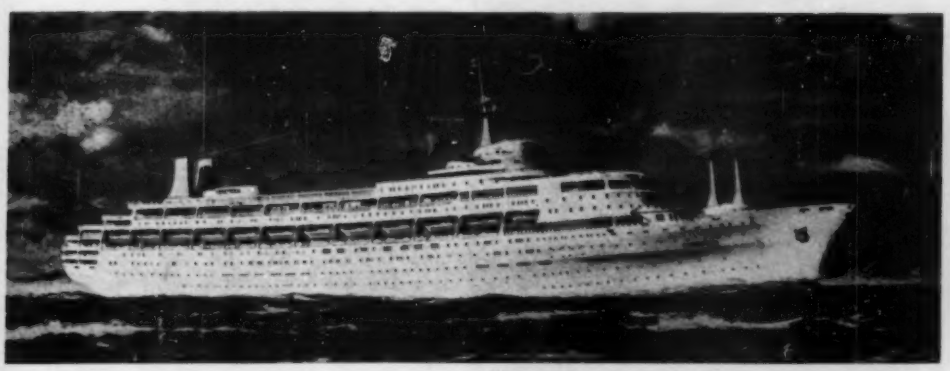




LIFEBOATS are stowed in two-deck-high bays. Compared with previous topside installations, the bays protect davits and lifeboats from weather and reduce maintenance requirements. The between-decks installation also lowers the ship's center of gravity.



FALLS are operated by winches mounted on the bulkheads. In case of power failure winches are cranked by hand.

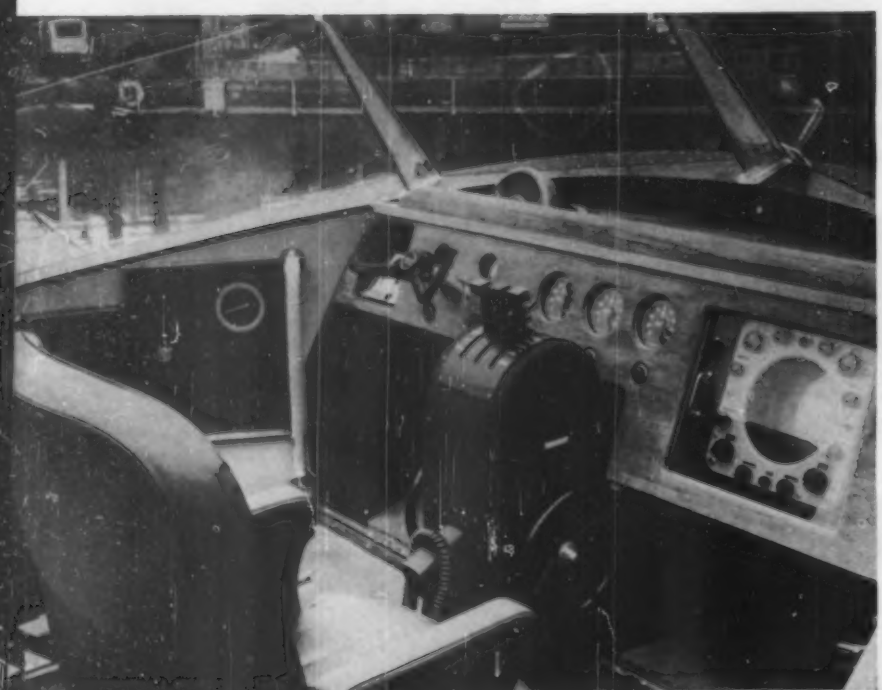


DAVITS for lifeboat stowing on the Canberra were designed and installed by Welin-Maclachlan Davits Ltd., London, England. Materials note: For strength, toughness, and resistance to salt-water corrosion, load-bearing members are made of 4.5 per cent nickel-aluminum bronze.

Airplane Controls Steer

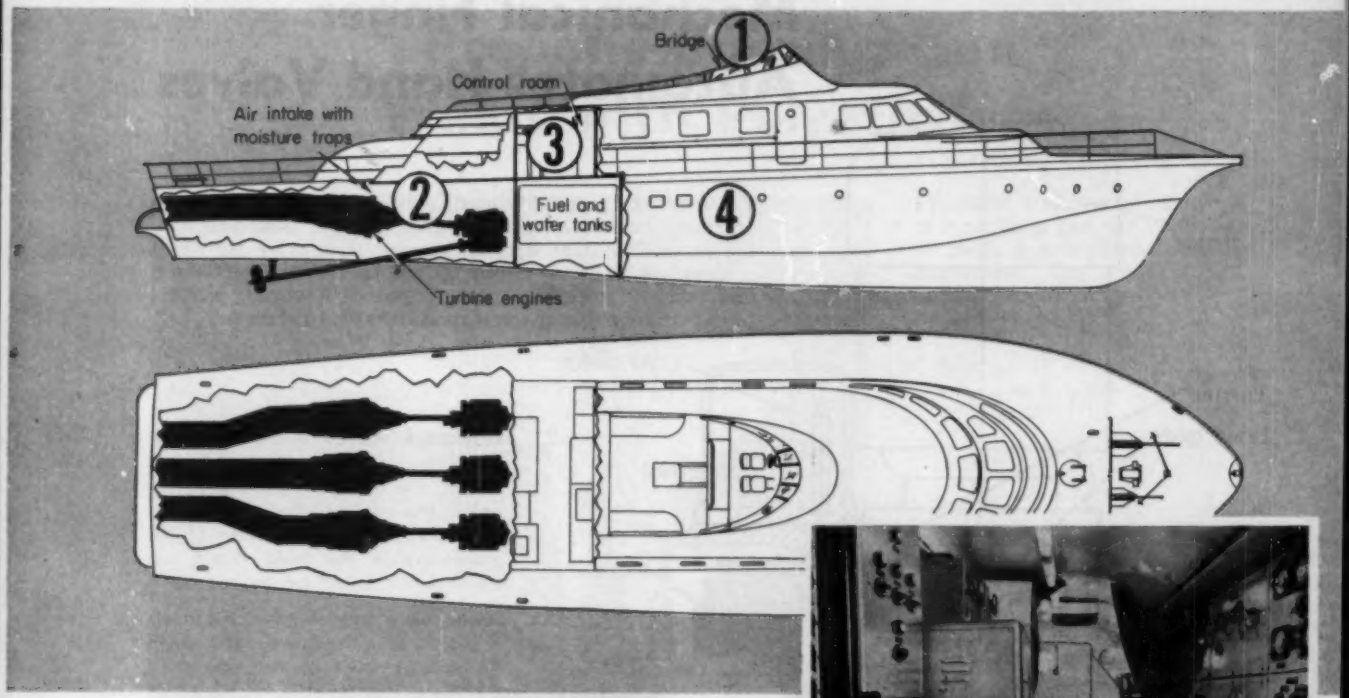
EXPRESS yacht Mercury was custom built for Mr. Stavros Niarchos by Vosper Ltd., Portsmouth, England.

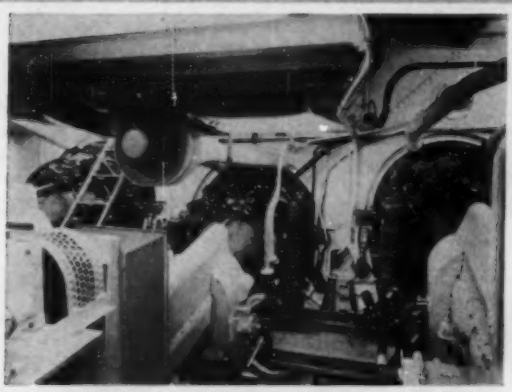
TURBOJET ENGINES drive the British-built Mercury at 54 knots. The open bridge looks like a cockpit with airplane-like controls. Conventional-looking, planing hull is of aluminum. Although designers considered such up-to-date innovations as hydrofoils and hovercraft, this hull design, also used in Britain's *Brave* class patrol boats, was considered better proven for use in open seas.



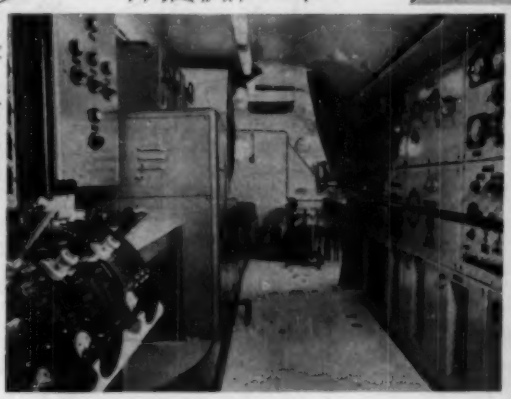
1 **ELECTRO-HYDRAULIC** vane-type steering motors are installed directly on each rudder stock. Airplane-type steering "stick" is connected by electric cable. A Sperry auto pilot is also included. Control to the auto pilot can be plugged in on the forecastle or on the after deck, as well as on the bridge. Overriding pushbuttons allow the hand-held auto-pilot control to maneuver the craft, and a microphone is included to pass orders to the engine room. Handwheels on the engine telegraph post adjust trim flaps.

Jet-Propelled Yacht

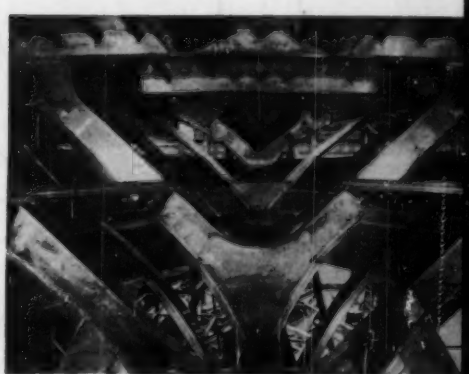




2 **TURBOJETS** propel the speedy craft. Three Bristol Siddeley marine Proteus gas turbines each drive a full-cavitation propeller through epicyclic reduction gears (housing in foreground). Air intake (overhead) is provided with splitters and water drains to keep sea water out of the turbines. In addition to these turbines, two 40-kw generators are driven by Rover gas turbines. All power aboard is thus gas-turbine generated. Since air conditioning throughout the ship makes heavy demands, generous storage batteries are provided to keep generators from operating during "silent hours."



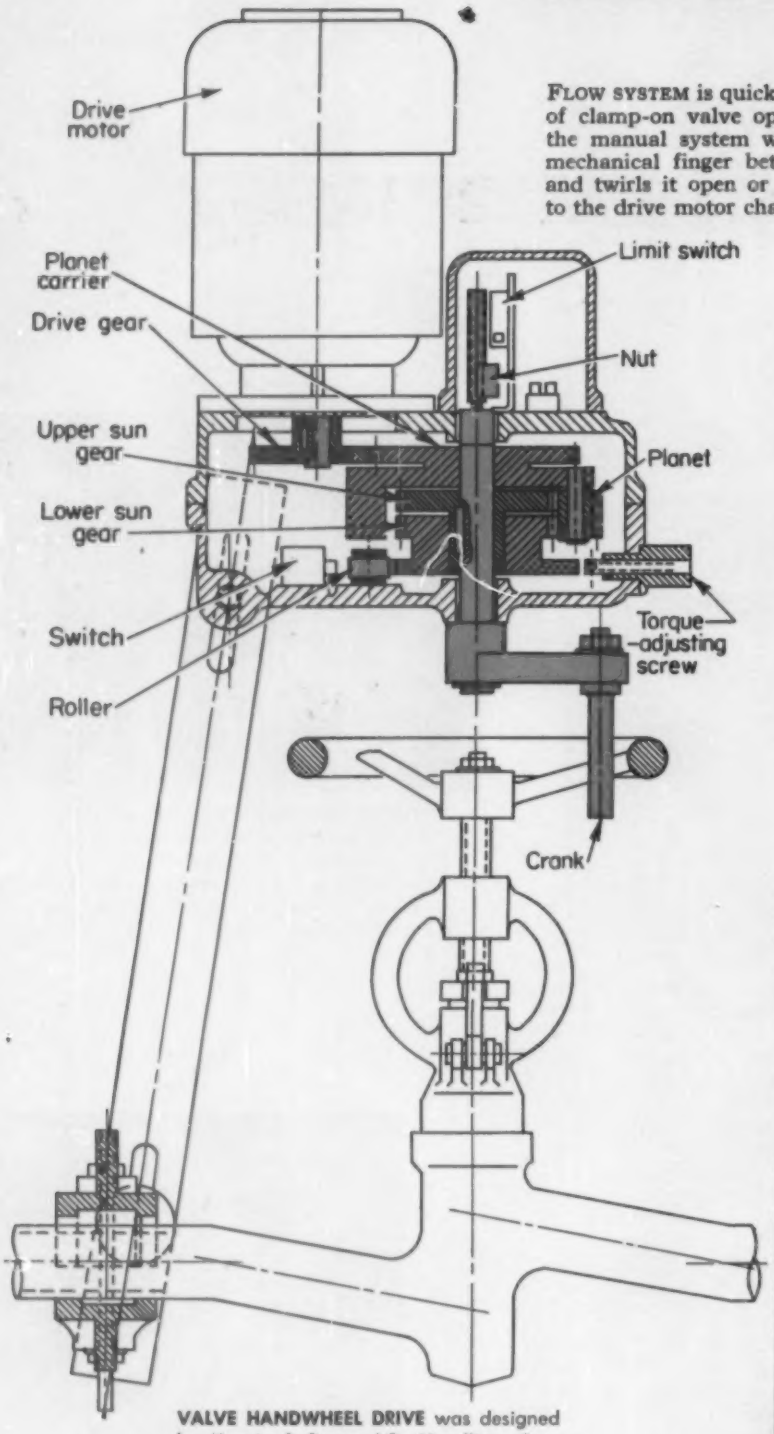
3 **ENGINE CONTROL ROOM** has air conditioning control panel (left) back of engine controls. Main switchboard is to the right. Communications center beyond has radio transmitter and receiver as well as telephone communication with the bridge.



4 **FRAMES AND BULKHEADS** are of aluminum alloy welded with argon-shielded arc. Double diagonal mahogany planking is bolted to the frames. Deck is of plywood with teak planking glued to it. Through fastenings are insulated with plastic bushings to prevent electrolytic corrosion.

Mechanical Finger Automates Hand Valves

FLOW SYSTEM is quickly made automatic with the addition of clamp-on valve operators that use the handwheels of the manual system without change. The drive thrusts a mechanical finger between the spokes of the handwheel and twirls it open or shut as required. Reversing current to the drive motor changes its direction of rotation.

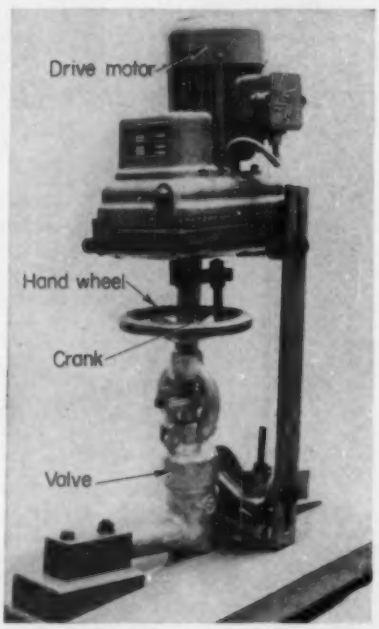


VALVE HANDWHEEL DRIVE was designed by Koenig & Bauer AG, Moedling, Austria.

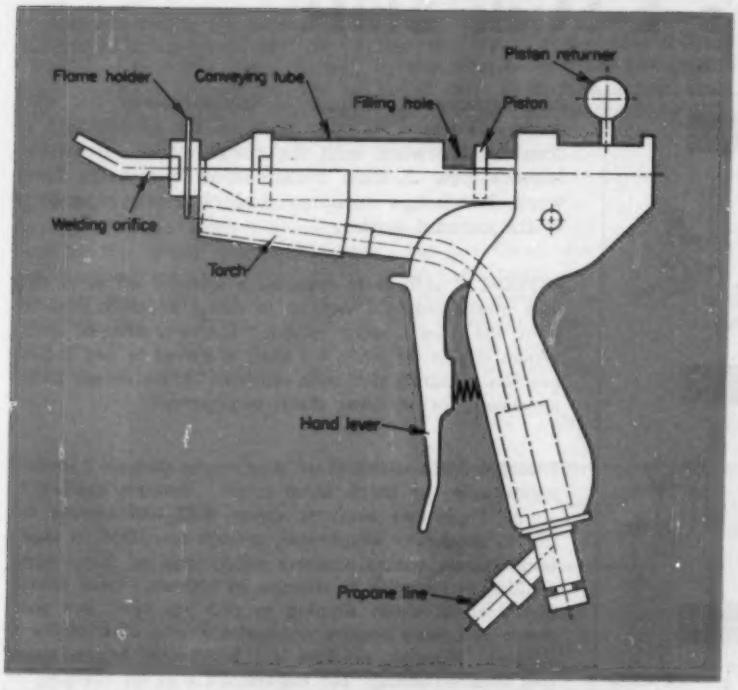
REVERSIBLE MOTOR drives the handwheel through a modified planetary system. The two sun gears differ by one in the number of teeth they possess. One complete revolution of the planet around the lower (fixed) sun advances the upper sun by one tooth.

Lower sun is fixed by a rubber roller in a groove. In the closing cycle, when the valve reaches its seat and stops the wheel, the roller is forced out of its groove and trips a switch shutting off the motor.

Opening cycle is limited by a screw and nut on the upper end of the crankshaft. As the valve opens, the nut moves up the screw until it trips a limit switch that shuts off the motor.

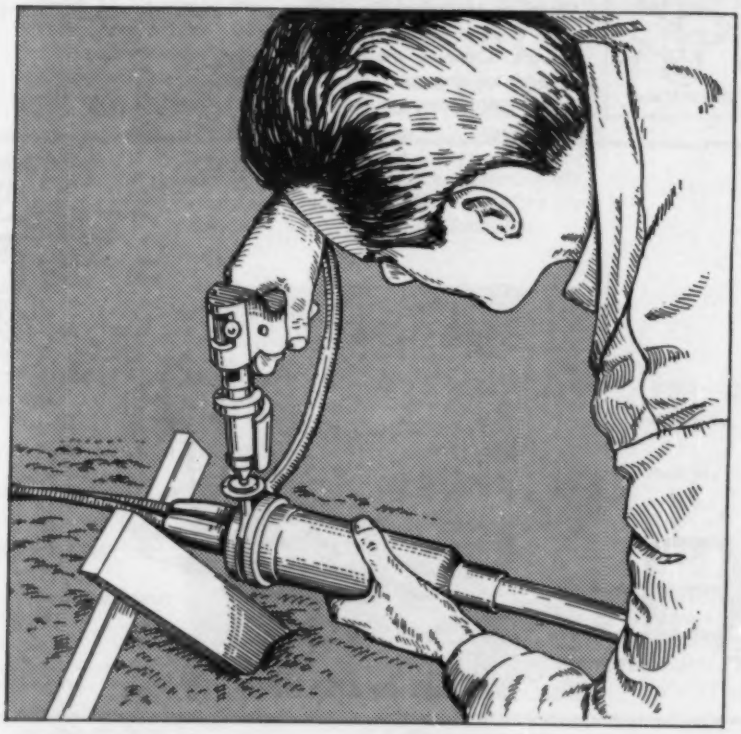


Propane-Burning Gun Welds with Polyethylene



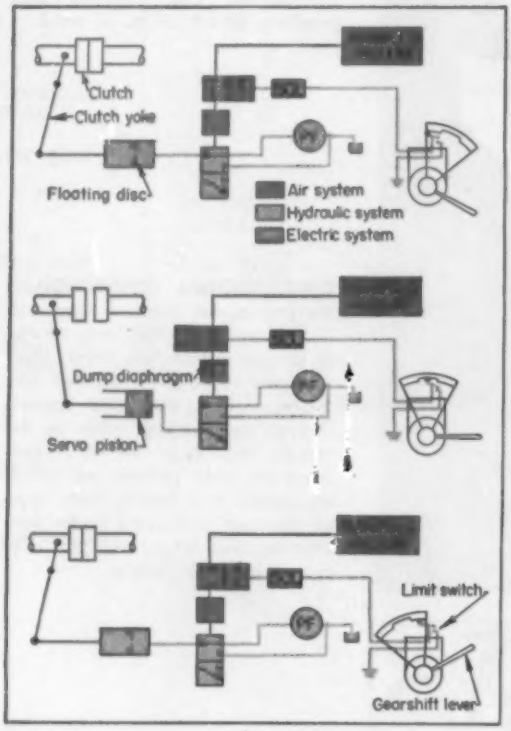
PROPANE TORCH and elements of a caulking gun are combined to make a new plastic-welding instrument. One loading will produce about 20 in. of weld.

ONLY EXTERNAL CONNECTION is the line to the propane supply. A needle valve in the base of the pistol grip adjusts the flame. Plastic weld material is loaded into the conveying tube and pressed through the welding orifice by the piston. Heat from the torch preheats the work surface and brings the plastic to a pliable state. Most of the heat is directed to the constricting area where the plastic is changing shape rapidly.



PLASTIC-WELDING GUN was designed by Siemens-Schuckertwerke AG, Erlangen, Germany.

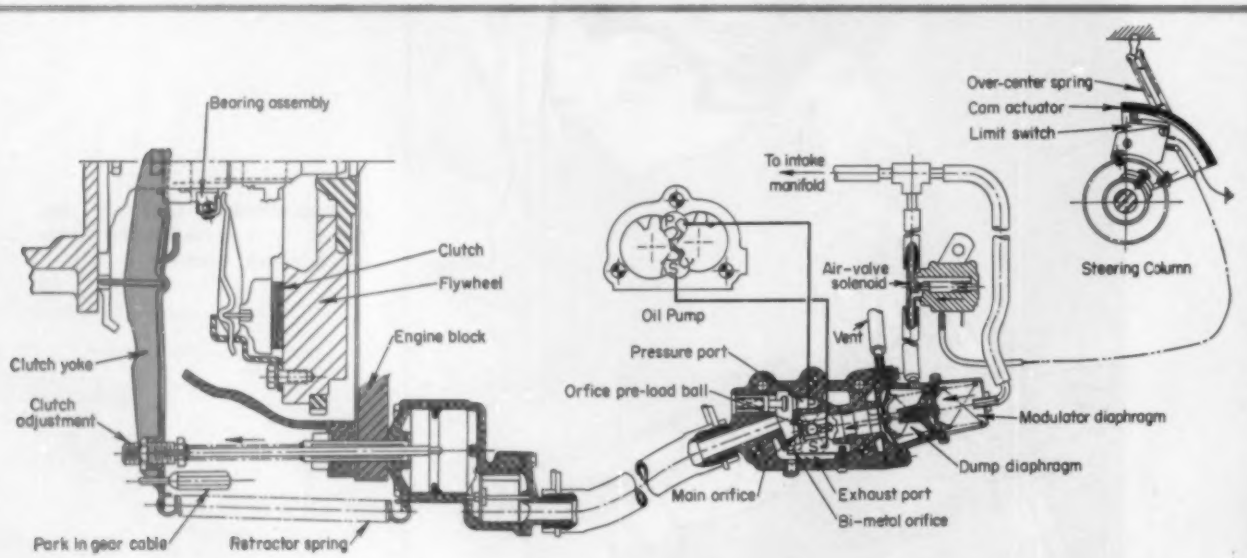
Manifold Controls Automatic Clutch In Rambler's E-Stick Shift



ATTRACTION of automatic transmissions for city drivers is based in large part on the elimination of constant footwork with the clutch pedal. American Motors new E-stick transmission eliminates footwork, but keeps economy and close driver control of the manual shifts.

MOTION of shift lever operates a solenoid air valve that uses intake-manifold vacuum to dump hydraulic pressure from the clutch servo system. Electro-pneumatic dump system is shut off when the lever is moved to any in-gear position. Floating disc with restricted orifice damps piston movement for smoother clutch engagement.

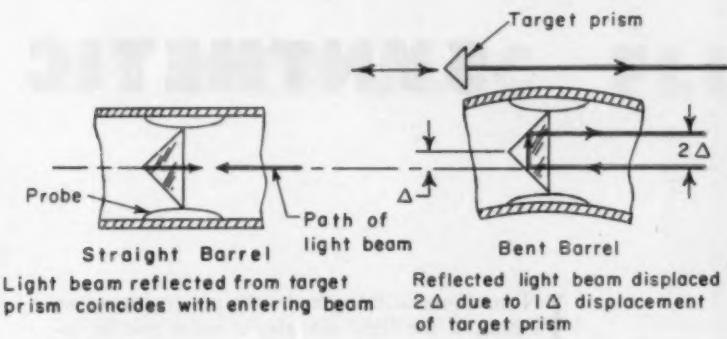
TANDEM ARRANGEMENT of diaphragms controls hydraulic pressure in the clutch servo circuit. Vacuum applied to either diaphragm tends to dump fluid and release the clutch. Modulator diaphragm, always connected to manifold vacuum, makes sensitive adjustments of dump spool position in response to changes in vacuum. These adjustments allow clutch slipping to pick up load, but push clutch into more positive engagement when the engine is lugging. Manifold pressure is a function of engine speed and throttle setting. For this reason it is an indicator of load or output torque. Idling with nearly closed throttle, the engine draws a strong vacuum and disengages the clutch. Opening the throttle destroys the vacuum and lets the clutch engage. Overspeeding engine with no load also tends to disengage the clutch, thus avoiding snap starts.

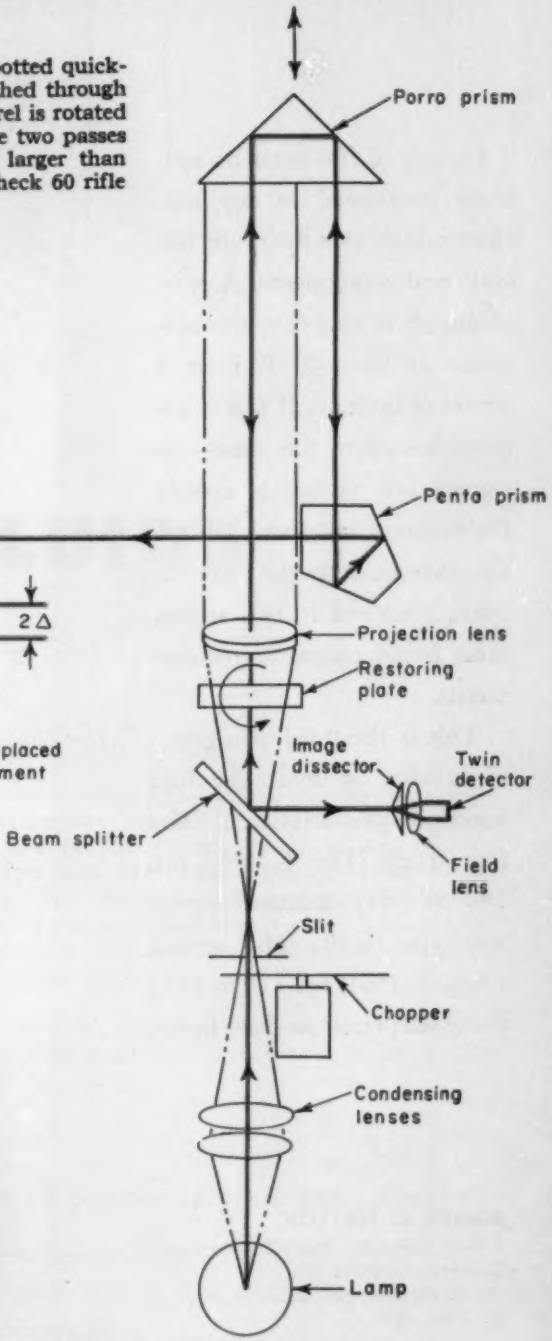


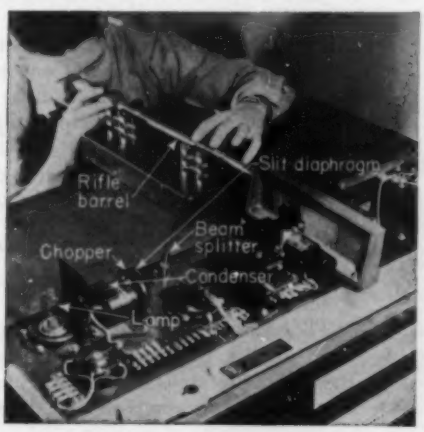
Sharpshooting Light Beam Spots 0.0003-in. Gun-Bore Deviations

MINUTE DEFLECTIONS in the bores of rifle barrels are spotted quickly and accurately by an optical checker. A probe is pushed through the barrel being tested and the results read out. The barrel is rotated 90 degrees and the test repeated. Information from these two passes gives position and magnitude of every bore deflection larger than 0.0003 in. in the barrel. Developers expect the unit to check 60 rifle barrels per hour.

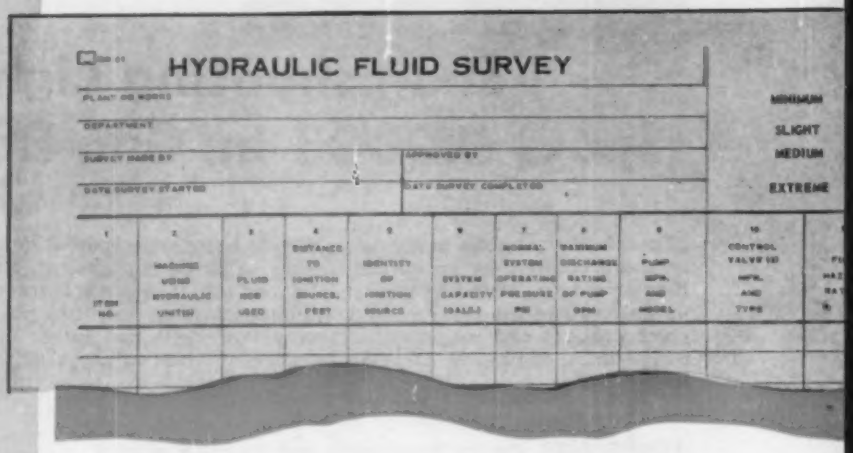
MOVING PARTS are the target prism and the porro prism. Motion of porro prism maintains a constant-length optical path as the target prism moves down the gun barrel. For an absolutely straight bore, the reflected light beam follows its own path back to the beam splitter where it is reflected into the image dissector, a flat, triangular prism. Two images of the projection lens are made on the twin detector cells (lead sulfide). As long as the images are equally bright, detector signals cancel each other. However, if the target prism is deflected as little as 0.0003 in. by a bent bore, the reflected beam does not fall evenly on the image dissector and the images are no longer equal in intensity. The resulting output signal turns the restoring plate until the image signals are equal again. Rotation of the plate is read by a potentiometer as a function of deflection.







HAIR-SPLITTING rifle bore checker was designed by Barnes Engineering Co., Stamford, Conn., under a contract with Associated Engineers Inc., Agawan, Mass. It will be used in the Springfield Armory.



SYNTHETIC

Danger of fire must be seriously considered in any machine which uses hydraulic circuits and components. A rule-of-thumb is to locate the machine at least 40 ft from a source of ignition. If this is impossible—often the case—designers are advised to specify fire-resistant synthetic fluids. Commercial or special formulations, described in this article, meet broad ranges of requirements.

This is the third of a group of articles on hydraulic-fluid selection considerations. The first article (Dec. 8, 1960, pp. 180 to 183) discussed emulsion-type fluids. The second (Aug. 3, 1961, pp. 114 to 117) discussed petroleum-base fluids.

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Monsanto Chemical Co.
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IN machines utilizing hydraulic power, proper selection of the fluid can play a major role in operational dependability. For installations where an ignition source will be within 40 ft of the hydraulic system—possibly even on the equipment itself—experience dictates the specification of a fire-resistant hydraulic fluid.

Among these fluids, the straight synthetic formulations, such as those based on phosphate esters or chlorinated hydrocarbons, offer maximum fire resistance coupled with outstanding lubricity, stability, and other desirable characteristics, Table 1. These properties tend to extend machine life, reduce downtime, and give exceptionally long service under extreme operating conditions, without excessive care.

In short, these fluids help equipment to deliver maximum performance even with inadequate maintenance. Because these synthetics contain only fire-resistant compounds, this lack of attention in no way decreases their safety factor.

There is a whole family of synthetic fluids, each with characteristics tailored for specific operating conditions.

The synthetics should not be regarded as expendable supplies, but rather as precision components in the hydraulic system. Use in industry has proved that, given the same periodic attention other pre-

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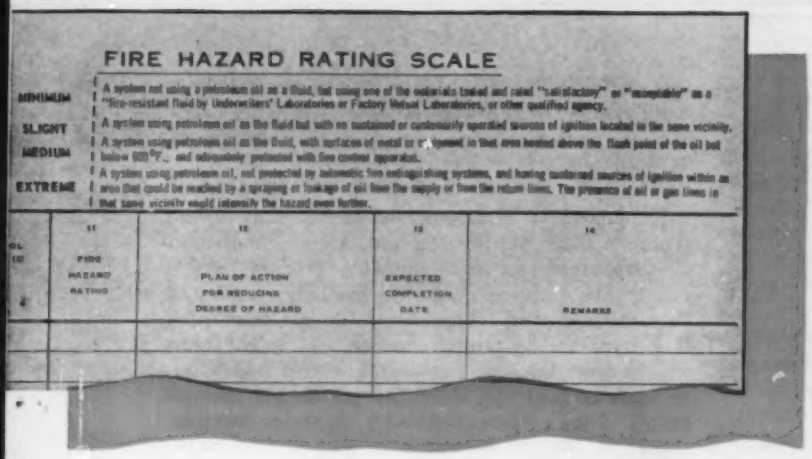

HYDRAULIC FLUIDS

cision parts should receive, synthetics have extremely long life.

Lubricity: These fluids have high film strength, load-carrying capacity, and overall lubricity, at least equalling that of petroleum hydraulic fluids. This, of course, is extremely important in insuring long life for vane, gear, and piston pumps, and other hydraulic system components.

These lubricating characteristics have been borne out in laboratory tests (Shell Four-Ball Wear Test, Timken Extreme Pressure Test, and the Almen Wear Test), pump tests, and more than ten years of industrial use. The synthetics tend to adhere to a metal surface more readily than do many petroleum products. This adherence results in the excellent film retention and high film strength which prevent metal-to-metal contact under severe conditions and prolong equipment life.

Operating Temperatures: These range from −65 to +300 F, depending on the base stock and the fluid

Advantages of Synthetic Hydraulic Fluids

- Excellent lubricity under heavy loads.
- Fire resistance at all times—no loss of protection due to evaporation.
- High resistance to oxidation.
- Good thermal stability.
- Low vapor pressure.

formulation. The fluids discussed here are only a small portion of the wide range of synthetics available for specialized operations—at temperatures of −100 or +800 F.

Flammability: The complete formulations of the synthetic fluids are fire resistant, not a combination of flammable and nonflammable products. As a result, they cannot evaporate partially, leaving a flammable residue. These fluids do not flash back if sprayed on an ignition source, but might burn with a low flame at the source. Most important, in years of field use, there has not been a case reported where a fire was caused by synthetic formulations.

Viscosity: Synthetic fluids are Newtonian in viscosity characteristics, available from 50 to 1000 SSU at 100 F. This range permits optimum matching of the fluid and system. Low-viscosity fluids are used most often for precision equipment or low operating temperatures. High viscosity fluids serve in heavy-duty applications. The most commonly used industrial synthetics are in the 230-SSU range at 100 F.

Some synthetics are formulated with viscosity index improvers. Mechanical shear does not change the viscosity of fluids without improvers, but it does reduce the viscosity of fluids with improvers. How-

typical applications for synthetic hydraulic fluids

Die casting machines
Hydraulic presses
Furnace tilters
Furnace door openers
Ingot loaders
Furnace regulators
Rotary furnaces
Molten salt baths
Extrusion presses
Plating machines
Electric furnace
Elevators and hoists
Hydromotors
Scarfers
Stampers
Hydraulic jigs
Operations
Forging
Permanent mold casting
Injection molding
Compressor lubrication

Table 1—Properties of Synthetic Fluids

Properties	Low-Viscosity Phosphate Ester-Base Fluid	High-Viscosity Phosphate Ester-Base Fluid	Chlorinated Hydrocarbon-Base Fluid
Intended Application	——Extreme conditions——		Average use
Viscosity (SSU at 100 F)	63	625	230
(SSU at 210 F)	35	46	42
Pour Point (F)	−70	20	10
Max Bulk Temp (long term) (F)	200	300	300
Coefficient of Thermal Expansion (per deg F)	0.00042	0.00041	0.00040
Specific Heat, at 77 F (Btu per lb per deg F)	0.42	0.32	0.28
Thermal Conductivity (Btu per hr per sq ft per ft per deg F)	0.047	0.065	0.06
Bulk Modulus (isothermal) at 77 F (psi)	328,000	375,000	400,000
Specific Gravity	1.00	1.36	1.42
Dielectric Strength (kv at 60 cps, 0.1 in., 77 F)	16	16	35
Autogenous Ignition Temp. (F)	895	1030	1220

ever, these fluids still retain better viscosity-temperature characteristics than the base stocks from which they were formulated.

The viscosity of the synthetics without viscosity-index improvers changes more with temperature variations than does that of petroleum hydraulic fluids. Generally, however, this is neither a design nor an operating problem because fluids are tailored for the specific temperature range under which they will operate.

Stability: These synthetic fluids do not oxidize, thicken and form sludge or varnish on long exposure to air as do petroleum fluids. They do not "wear out" in use, and do not require changing, draining or periodic adjustment, other than normal make-up requirements.

Corrosion and Rust: Synthetic formulations offer no corrosion problems with common metals. However, moving parts made of aluminum should be anodized to prevent excessive wear.

These fluids will not cause rust on the surfaces they contact. But rusting can occur if moisture condensation takes place in the reservoir above the fluid. For special cases, the fluids can be formulated with rust inhibitors.

Compressibility: The bulk modulus of the fluids based on phosphate esters and chlorinated hydrocarbons is over 300,000 psi, well above oil or most other hydraulic fluids. Thus, fluid compressibility is low, contributing to a crisp, high-response system.

Foaming and aeration properties similar to those of oils of comparable viscosity are achieved by formulating the synthetics to control foam. This, too, contributes to a positive-acting system.

Specific Gravity: The synthetics are heavier—1 to 1.5 specific gravity—than most other hydraulic fluids, so pump intake ports must be large enough to move the fluids satisfactorily.

Large ports are now generally accepted as desirable for all fluids.

Intake piping should not be restricted and the distance from the reservoir to the pump should be short. Otherwise, good fluid system design answers all the requirements of the synthetics arising from specific gravity differences.

Solvent Action: Solvent characteristics of the synthetics keep a new system clean, and tend to clean up a system converted from petroleum oil by dissolving such contaminants as sludge and varnish. Additives which serve a variety of purposes are easily dissolved in the phosphate ester or chlorinated hydrocarbon base.

There are no adverse effects on such components as gaskets and seals designed for use with these fluids. Component materials include butyl, Viton A, or silicone elastomers. Special pipe dopes and paints (epoxies, hard-cured phenolics, or nylon-based), are commercially available and should be specified. Where electric wiring will be subjected to frequent wetting by the fluid, the wire should be nylon-insulated.

Filtration: Particle suspension is no problem with extremely fine filter porosities. Metal filters down to 10 microns and active-earth filters to 3 to 5 microns can be used. The latter are recommended because they take out moisture and keep acidity low in addition to removing solids.

Screens of 60 to 100 mesh, the same size used for petroleum fluids, are also suitable for synthetic formulations. The periodic use of a portable pump-filter combination is recommended, particularly when no filter is provided on the machine itself. This can be attached to the system without interrupting normal operation.

If a break should occur, synthetic fluids can be saved, filtered, and re-used. Similarly, if a fluid should be contaminated with water, it can be readily recovered because the two do not mix.

Fluid Compatibility: The synthetics are not compatible with water-based fluids. Most petroleum oils dissolve in synthetics, but this action is not desirable because even a small percentage of oil in a synthetic will reduce its fire resistance.

Phosphate ester-based fluids are not necessarily compatible with straight phosphate-ester fluids in all proportions. However, chlorinated-hydrocarbon-base fluids are completely compatible with all synthetic fire resistant fluids now used.

Toxicity: These fluids are comparable, generally, to petroleum oils in respect to toxicity. They are designed for use in a closed system. In years of actual operation, there has never been a report of a permanent injury from the fluid.

Cost: Initial cost of filling a system with a synthetic formulation is higher than with other hydraulic fluids. However, it is worth considering that a die-casting machine costs $50,000 to $200,000, and a single set of dies may run as high as $100,000. With downtime on the equipment charged off at about $75 to $150 per hour, it seems questionable economics to object to an initial investment in 150 to 200 gallons of synthetic fluid at $3 to $3.50 per gallon.

Also, fluid make-up costs are low due to the long service life and reclaimability of the synthetic.

a guide
to the selection of

Indicator Lights

JOSEPH L. SEMINARA
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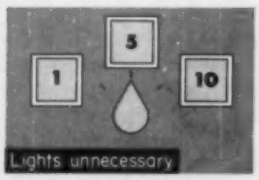
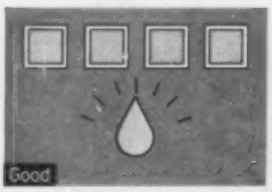
LIGHT displays provide necessary information concerning the status of machines, processes, and equipment. Because numerous types of indicators are available, selection is often hasty or careless and based only on a superficial investigation of electrical characteristics.

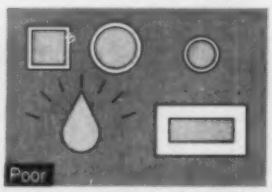
Equally important in the selection of indicator lights, however, are human engineering criteria. These criteria are the source for the recommendations and methods of evaluation presented here. The rewards are improved over-all equipment appearance, reduced panel space, increased reliability, simplified maintenance, and more efficient operator performance.

Functional Objectives



Indicator Use: Indicator lights are essentially attention-getting devices and should be used to indicate important aspects of equipment functioning. Generally, indicator light should not be used primarily to display toggle or rotary-switch positions.





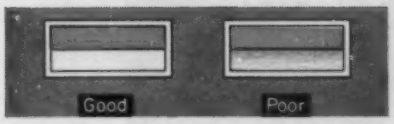
Appearance: Although purely a subjective factor, external appearance is judged as a part of the equipment effectiveness. Therefore, indicator lights should enhance the over-all appearance. Where several consoles or units are intended for the same installation, light displays should be standardized for visual harmony as well as parts interchangeability. Indicators should satisfy both functional and appearance criteria without sacrificing either human engineering or esthetic considerations.

Recommended Colors: Display units for an equipment system should have provision for accommodating green, red, yellow (or amber), and white colors. In some systems, blue is also required. Basic indicator colors and their usual meanings are listed.

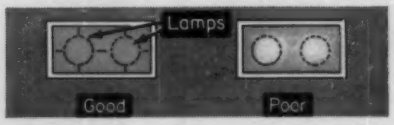
Color	Usual Meaning
Green	Safe; in tolerance; go; normal.
Yellow	Marginal; approaching a "no go" condition.
Red	Danger; "no go"; out of tolerance; abnormal.
Blue	Commands performance of control actions from other equipment stations.
White	Status functions with no implication of normal or abnormal condition; for example, power on.

Circle 22-6 on Page 19 for extra copy.

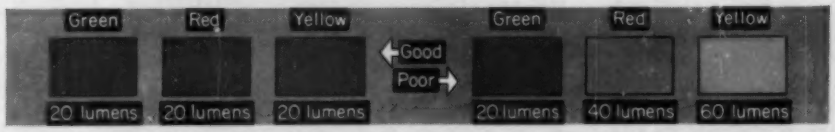
Illumination



Light Spread: Many indicator-light caps can be split vertically or horizontally so that one indicator serves double duty. When this feature is used, no light should be allowed to leak from one sector to the other.

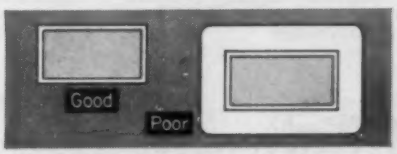


Light Concentration: The legend cap should diffuse light evenly across the indicator face. Avoid the use of indicators that create "hot spots."

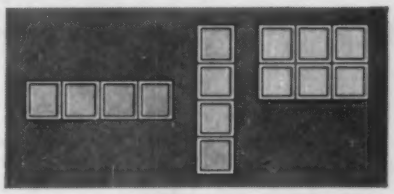


Lamp Brightness: Indicator lights should be equally bright for all colors; that is, an amber light should not be brighter than adjacent red or green lights. Excessively bright indicators which produce annoying glare should also be avoided.

Indicator Spacing

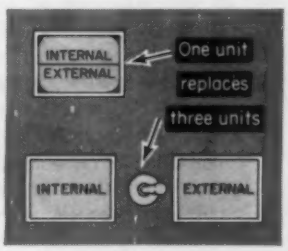


Legend Area: If panel space is at a premium, the required legend area for all the conditions that must be indicated should be determined. Then, indicators with the least wasted space, or which will fit on a proposed panel, can be selected. When panel area must be increased because bulky indicators were carelessly chosen, total cost of the equipment can increase rapidly, particularly if a second console is required.

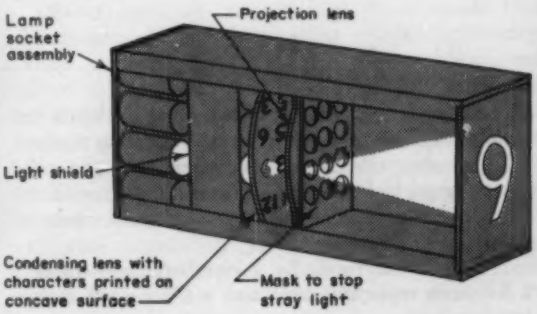


Grouped Units: Square or rectangular indicators which can be readily stacked in a horizontal or vertical array can save valuable panel space and yet permit esthetic arrangements. Groupings of circular indicators do not result in similar space savings. Indicators selected for multiple arrangements should include provision for easy wiring of the units.

Surface Projections: In general, indicators which can be flush mounted are the most satisfactory. Indicators that project from the panel frequently restrict the operation of near-by controls and therefore increase requirements for panel space. Also, the indicator caps are likely to be dislodged or damaged. When projecting indicators are mounted above or below eyelevel, they tend to obscure adjacent panel labels.

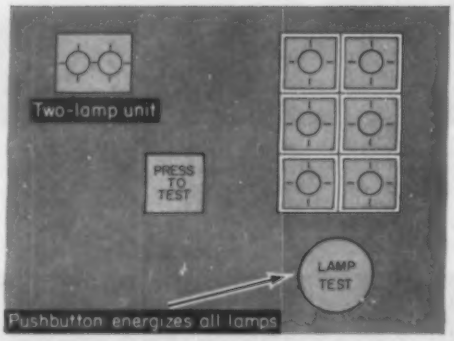


Combination Units: Panel design can be simplified with the use of switchlights. These devices perform the function of two separate indicators and a control. However, where simple indicators and switchlights are intermingled on a panel, a distinction must be made between the two types. One coding technique is to darken the corners of switchlight legend caps.

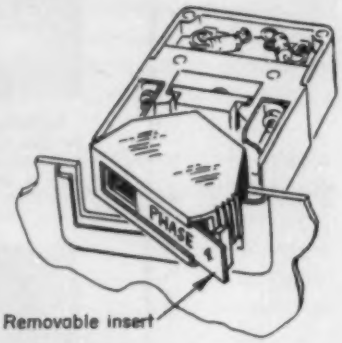

Lamp socket assembly
Projection lens
Light shield
Condensing lens with characters printed on concave surface
Mask to stop stray light

Multilegend Units: Another relatively new type of indicator is the projection-type display. With these units several separate messages can be displayed on the same indicator screen. They are useful where sequential events or only one of several mutually exclusive conditions are to be indicated. The panel space required by a multilegend unit is only slightly more than that required by one standard-size four-bulb indicator.

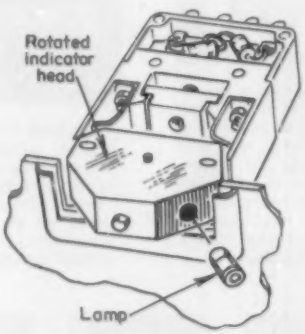
Reliability and Maintenance



Indicator Reliability: The simplest and most common means for ensuring an indication when it is needed is the use of indicators which incorporate two lamps per color. Both lamps will rarely burn out at the same time. Single-bulb indicators should either be the press-to-test type or be provided with test circuitry for checking all lamps prior to equipment operation. Indicator reliability is especially important when the absence of an indication signifies a malfunction.



Legend Changes: When an indicator is to be used for different or modified programs, buying a new indicator cap for each legend change can be expensive and inconvenient. For such applications, indicators which include quick and easy means for changing legendry should be selected.



Lamp Replacement: Because indicator lamps seldom burn out at convenient times, efficient replacement should be provided for. Ideally, lamp replacement should be accomplished from the front of the panel and without special tools. If a tool is required, it should be commonly available—a screwdriver, for example.

Keyed Caps: Removal of the indicator cap is usually necessary when a lamp is replaced. When several caps are removed at a time, it is possible to mismate legendry and indicator. Misidentifications could prove costly to personnel safety or in equipment malfunctions. For indications of hazardous conditions, indicator caps should be physically keyed so that mismatings are prevented.

Tips and Techniques

Repeating Decimals

Fractions corresponding to repeating decimals can be found quickly and easily by the following method.

1. Ignoring the decimal point, subtract the nonrepeating part of the decimal from the original number up to the point where the second cycle of repetition begins.

2. Divide the result by a number made up of a 9 for each repeating digit and a 0 for each nonrepeating digit.

Example 1: Find the fraction corresponding to 0.35270707 etc.

First, subtract the nonrepeating part of the decimal from the decimal up to where repetition begins, ignoring the decimal point: 35270 − 352 = 34918. Divide this by 99000 to get 34918/99000.

Example 2: Find the fraction for 0.252525 etc.

Since there is no nonrepeating part, simply divide 25 by 99 (for the repeating part).—FRANK MURRAY, *Chicago, Ill.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Hydraulic Pumps and Motors

In the August 31, 1961 issue, Page 94, the ordinate of Fig. 1 should be labeled Coefficient of Dry Friction, C_d.

O. J. ZAMPARO
Project Engineer
MB Electronics
A Division of Textron Electronics Inc.
New Haven, Conn.

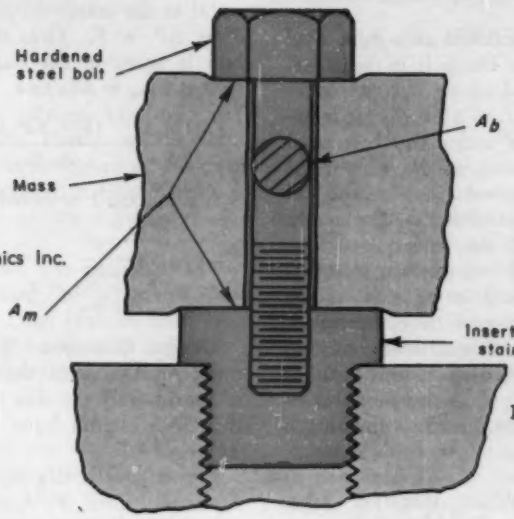


Fig. 1—Simple mass-bolt system.

Design recommendations for

Keeping Bolted Joints Tight

under severe vibration conditions

WHEN bolted joints vibrate, decoupling is always a potential problem. As defined here, decoupling is the separation of two masses which are intended to vibrate in unison.

To avoid this condition, bolted joints for vibration service should be designed with the decoupling problem in mind. Recommended practices which tend to minimize the problem are presented in this article. Although based on the performance of a bolted joint on a vibration exciter, the concepts discussed are applicable in principle to any joint held together by threaded fasteners.

Influencing Factors: What causes decoupling? It may result from acceleration forces on a joint member overcoming bolt forces, and/or from axial resonance of the bolts themselves.

First to be considered is the case where the mass of one joint member is smaller than that of the other member and acts upon the fasteners as springs. Under certain vibration conditions, the force developed by the acceleration of the smaller mass becomes greater than the force of the bolts holding it to the larger member.

Based upon the relationships, force equals mass times acceleration, acceleration equals displacement times the square of the frequency (rad/sec), and force equals deflection times spring rate (force per unit deflection), it can be shown that spring rate equals mass times the square of the frequency when displacement becomes equal to deflection.

This means that the stiffness, analogous to the spring rate, must rise as the square of the frequency to avoid decoupling. More specifically, the total relaxation of deflection between the mating parts must be less than the least deflection produced by tightening the bolts.

Simple Mass-Bolt Systems: Analysis can be made of a simple mass-bolt system to determine the preload required to avoid decoupling. This analysis can be readily extended to more complex structures.

In Fig. 1, a bolt of cross-sectional area A_b is used to constrain the mass. When the bolt is tightened, it stretches an amount δ_b and causes a compressive deflection δ_m in the mass over an area A_m. It is assumed that the stressed area under the bolt head is the same as the stressed area at the mass-insert interface. Further, it is assumed that, because of extreme stiffness, negligible deflection takes place in the hardened bolt head and the insert.

Tensile load P is introduced into the bolt by tightening. The bolt is prestressed in tension and a section of the mass is prestressed in compression. Each deformation, δ, is proportional to the relative stiffness, K, of the part, according to the relation $\delta = P/K$ where $K = EA/L$; E is the modulus of elasticity, A is the stressed area, and L is the length of the deformed part.

Reaction to Vibration: When vibration takes place, the mass exerts an additional fluctuating force, F, on the bolt equal to the mass times the acceleration. While this force is acting in a direction away from the insert, it tends to stretch the bolt by an amount ΔL_b. A release of deflection ΔL_m is produced in the mass which approximates ΔL_b up to the point of separation. Separation occurs if ΔL_b exceeds δ_m or if the bolt fails or yields excessively.

Under action of force F, the residual load on the mass is $P - \Delta P$, where ΔP is any load decrease less than the prestress load. The new bolt load is equal to the compressive load of the mass plus F, or $P - \Delta P + F$. Thus the change in length of the bolt is equal to the change in length of the mass so that $\Delta L_m = \Delta L_b$ and

$$\frac{\Delta P\, L}{A_M\, E_M} = \frac{(F - \Delta P)L}{A_b\, E_b} \qquad (1)$$

If Equation 1 is solved for load decrease,

$$\Delta P = \frac{F}{\dfrac{A_b\, E_b}{A_m\, E_m} + 1} \qquad (2)$$

Design Concepts: To prevent decoupling, the mass must remain deflected upon the occurrence of maximum force due to acceleration. This implies that the residual force on the mass must not drop to zero.

Fig. 2 graphically represents these circumstances. Dynamic force F due to acceleration fluctuates about the level of prestress force P. This level of prestress is attained as a result of the bolt extension, δ_b, and the mass compression, δ_m, reaching a condition of equilibrium. These static deflections are determined by the stiffness K of the respective materials. However, the deflection of the combination due to the action of the dynamic force F is determined by the stiffness of the assembly, K_a. When the deflection of the system reaches the deflection of the least statically deflected component—the mass in this case—separation is imminent. Since

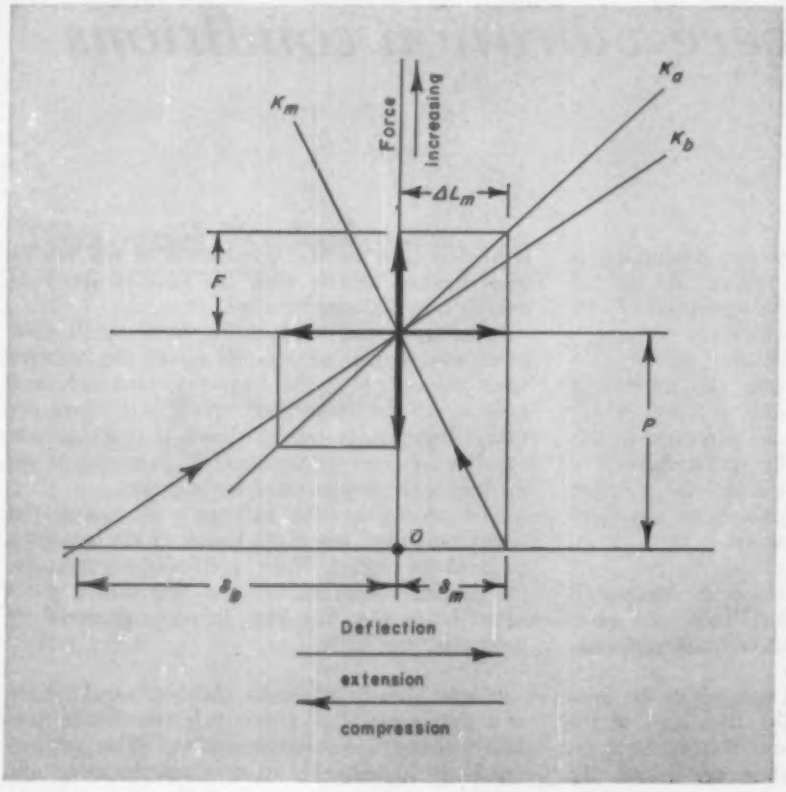


Fig. 2—Mass-bolt loading diagram.

stiffness $K = AE/L$, the load decrease is

$$\Delta P = \frac{F}{\frac{K_b}{K_m} + 1} \quad (3)$$

Equation 3 shows that bolt stiffness in excess of mass stiffness can diminish the change in preload to a fraction of the force due to acceleration. Consequently, the prestress required with relative stiffnesses of this order need not be much geater than F to insure seating with safety.

If bolt stiffness is less than the mass stiffness, K_b/K_m approaches zero, making ΔP approach F. Therefore, a greater portion of the preload must be retained to keep the joint tight. This situation is the more common; it is also more critical for unseating.

Prestressed Bolts: To be on the safe side, bolts should be prestressed so that the total joining force is at least 10 per cent greater than the calculated separating force due to acceleration at the highest anticipated frequency. It is difficult to determine precisely the force in the bolts, especially since friction accounts for a large portion of bolt torque.

A simple approach to this problem is to first determine the number, length, and size of the bolts. Check a few bolts for the applied torque that causes failure under test conditions. Then, as a rough rule of thumb, tighten the bolts to 80 per cent of the breaking torque determined.

At best, a torque wrench indicates only an approximate clamping force. A more exact way to determine clamping force is by measurement of bolt elongation or strain. However, this method of approach has certain limitations, not the least of which is cost.

Resonance Conditions: At resonant frequency, the displacement amplitude of a bolt-mass system increases and can cause complete separation of a bolted joint. The problem is to find frequency f_r at which separation occurs.

Fig. 3, a schematic of Fig. 1, shows K_b and K_m as "springs" in parallel. Here $K_a = K_b + K_m$. Damping is considered negligible. From the relationship for natural frequency,

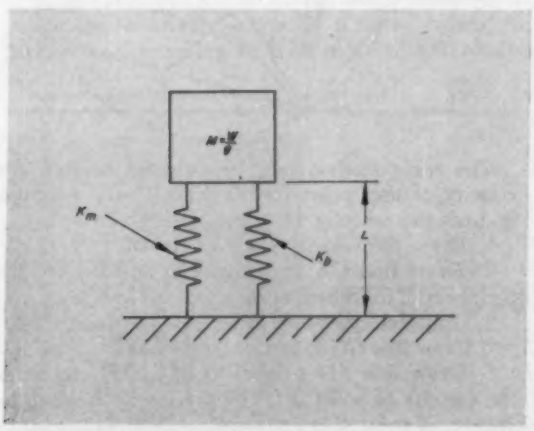


Fig. 3—Schematic of simple mass-bolt system.

$$f_r \approx \frac{1}{2\pi}\sqrt{\frac{K_b + K_m}{M}}$$

$$\approx \frac{1}{2\pi}\sqrt{\frac{(A_b E_b + A_m E_m)g}{LW}} \quad (4)$$

where W is the weight of the bolt-mass system, lb, and g is the acceleration of gravity, in./sec/sec. Actual frequency values differ somewhat from those calculated from Equation 4. These differences are attributed to the simplifying assumptions about the distribution of stresses within the bolt-mass system. Nevertheless, avoiding the approximate frequency range indentified with Equation 4 is the simplest way to prevent decoupling because of resonance. Otherwise, the problem can be minimized by following bolting practices previously discussed.

If the preload on the system is insufficient to maintain deflection in the mass, resonant frequency is

$$f_{rb} = \frac{1}{2\pi}\sqrt{\frac{A_b E_b g}{LW}} \quad (5)$$

This frequency is lower than f_r since one of the parallel springs, K_m, is inactive. This shows that proper bolt tightening may raise f_r above the operating frequency under service conditions.

Axial Bolt Resonance: A second major cause of decoupiing is axial resonance of the fastening bolts. Axial resonance becomes apparent when the bolt itself vibrates in the mode characterized by alternate lengthening and shortening in the axial direction.

The frequency at which axial resonance occurs is

$$f_{ra} = \frac{1}{2L}\sqrt{\frac{Eg}{\rho}} \quad (6)$$

where L is the free length of the bolt, E is the elastic modulus of the bolt material, and ρ is the weight density of the material.

It is evident that for a given bolt material, length L is a critical dimension. Since the ratio of E/ρ is nearly the same for those common bolt materials which yield the highest resonant frequency ($E/\rho = 100 \times 10^6$ in. for steel, aluminum, magnesium, and titanium) the only factor which can be readily varied is bolt length. However, a measurable increase in frequency can be obtained by using beryllium for which $E/\rho = 560 \times 10^6$ in.

Bolt Length: In general, it is best to select as short a bolt as practical to raise f_{ra} to its maximum value, which should fall above the operating frequency range. However, in addition to physical limitations, bolt length may be limited by the energy absorption potential required to prevent failure. In cases where a joint member is subjected to high accelerations or shock, short, highly stressed bolts may fail at the root of a thread because of their inability to yield and absorb the high impact energy. Use of a larger number of bolts turned to thread root diameter along the free length may prevent failures of this type.

Calculation Example: A motor is bolted to a rolling bed. Under service tests, the bolts tend to loosen

during operation, regardless of lockwashers. Analysis of the operating conditions indicates that a frequency of 850 cps, which is a harmonic of the rolling frequency, is causing decoupling of the motor from the bed-plate. While the load on the motor bolts is relieved, the bolts vibrate loose.

The motor, which has a very stiff cast-aluminum case, weighs 38.6 lb. There are four steel hold-down bolts of ¼-in. diameter with a free length of 2 in.

SOLUTION: From Equation 6, lowest frequency of axial resonance of the bolts is:

$$f_{ra} = \frac{1}{2(2)}\sqrt{\frac{30(10^6) \times (386)}{0.283}} = 50{,}500 \text{ cps}$$

This frequency is high enough to be ignored.

In this example, bolt failure is not a problem. Free bolt length is unthreaded and area is calculated using full diameter of the resonating shank. Thus, for the bolts considered as springs,

$$K = \frac{AE}{L} = \frac{0.196(30)(10^6)}{2} = 2.95 \times 10^6 \text{ lb per in.}$$

From Equation 5, for the mass of the motor on the bolts as springs,

$$f_N = \frac{1}{2\pi}\sqrt{\frac{2.95(10^6)}{\frac{38.6}{386}}} = 864 \text{ cps}$$

This frequency is close to the 850 cps disturbing harmonic. The bolts should be tightened, if possible, to preload the material in the motor-case flange. Tightening the bolts to 50 lb-in. gives approximately 5000 lb clamping force, which had not been obtained prior to decoupling.

The K value for the motor case flange area depends on many factors, such as washer size, hole size, surface condition, etc. Here, K was found to be 2.65×10^6 lb per in. Natural frequency of preloaded bolt-flange system is:

$$K_{total} = K_{bolts} + K_{flange}$$
$$= 2.95 \times 10^6 + 2.65 \times 10^6 = 5.60 \times 10^6 \text{ lb per in.}$$

$$f_N = \frac{1}{2\pi}\sqrt{\frac{5.60(10^6)}{\frac{38.6}{386}}} = 1190 \text{ cps}$$

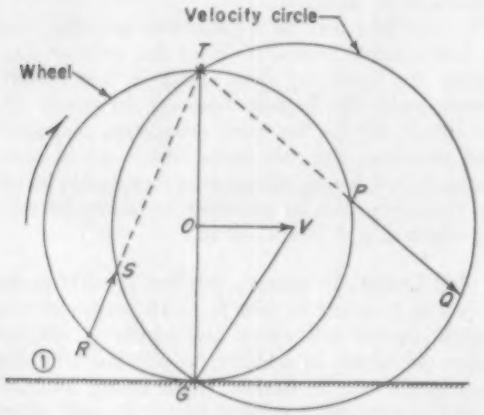
This frequency is sufficiently in excess of 850 cps to arrest decoupling.

Tips and Techniques

Velocity of Point on a Wheel

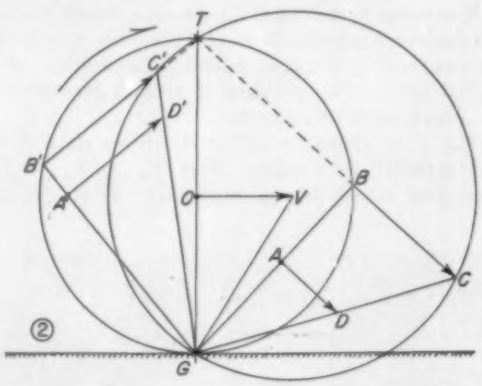
The following graphical method can be used to determine quickly the instantaneous velocity of any point on a wheel rolling in a straight path without slip. All that is necessary is the velocity of the center of the wheel.

To find the velocity of a point on the periphery of the wheel, Fig. 1:



1. Draw velocity vector OV, representing the velocity of the center of the wheel, to any scale.
2. Using point V as a center, draw the velocity circle, with radius GV.
3. The velocity of any point on the periphery of the wheel can be determined by simply drawing a line from point T through the point on the periphery, so that the line intersects the velocity circle. The required velocity is that part of the line extending from the point on the periphery to its intersection with the velocity circle. Direction of velocity is from the wheel to the velocity circle.

EXAMPLE: The velocity of point P, Fig. 1, is found by first drawing line TQ. Velocity of P is, then, represented by PQ. By the same method, velocity of point $R = RS$.



The same method can be extended to find the velocity of any point on the wheel. For example, to find the velocity of point A, Fig. 2:

1. Draw the velocity circle as shown.
2. Draw line GA and extend it to intersect the periphery of the wheel at B.
3. Draw velocity vector BC.
4. Draw line GC to form triangle GBC.
5. Draw line AD parallel to BC. AD represents the velocity of point A. The process for finding the velocity of point A' is also shown.—S. M. LOUNSBERRY JR., *Moore & Steele Corp., Owego, N. Y.*

A simplified, direct procedure for

Designing Minimum-Section Columns

B. SAELMAN and **A. E. RUBIN**
Design Weight Engineer — Design Specialist
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STRESS developed in a column or wide panel under compression loading can be determined from the product of

- A term representing material strength.
- A loading term.
- A factor determined by section shape.

On a strength-weight basis, optimum design of such columns requires the minimum-area section giving the maximum allowable stress consistent with the loading term. Since this allowable stress is proportional to the value of the shape factor, the optimum section is attained when the value of this factor is a maximum.

This article presents a simplified, direct method for determining shape factors and optimum proportions of column sections, such as I-sections, channels, tees, etc., under pure compression loading. Similar procedures for tubular columns in compression and bending are detailed in earlier articles.[1,2] Optimum proportions for combined loadings, such as compression and shear, would differ somewhat from those obtained here.

Symbols are defined in Nomenclature.

Basic Concepts: For a column under compression, maximum allowable stress is attained when the stresses corresponding to each mode of failure, and the applied stress, are equal.[3] Accordingly, when $\sigma = \sigma_{col} = \sigma_{cr}$,

$$\sigma^{5/2} = \sigma_{cr}{}^{1/2}\,\sigma\,\sigma_{col}$$

$$= \pi^2 K_e{}^{1/2}\,\eta_c{}^{1/2}\,\eta_t\,E^{3/2}\left(\frac{\rho^2}{A\dfrac{b}{t}}\right)\left(\frac{P}{L'^2}\right) \qquad (1)$$

The first term, $K_e{}^{1/2}\eta_c{}^{1/2}\eta_t$, is a function of basic material properties; the second factor, $\rho^2/(Ab/t)$, is a measure of the shape effectiveness of the section; and the third factor, P/L'^2, represents the loading

[1]References are tabulated at end of article.

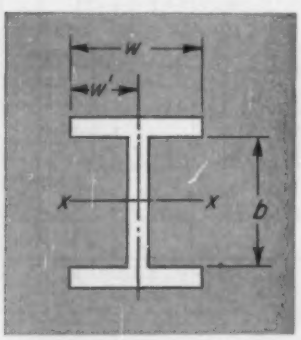


Fig. 1 — Typical I-beam section for column under compression loading.

Nomenclature

A =	Area of column section, sq in.
b =	Length of section or plate element, in.
C =	End-fixity coefficient, which varies from 1 for simple support (pin ended) to 4 for fixed support
E =	Young's modulus of elasticity, psi
E_t =	Tangent modulus (slope of stress-strain curve in the the plastic range), psi
I =	Moment of inertia of column section about neutral axis, in.^{4}
K_e =	Edge-restraint factor
k_{sx} =	Shape factor for bending of the column about the X-axis
k_{sz} =	Shape factor for bending of the column about the Z-axis
L =	Actual column length, in.
L' =	Effective column length, in. $= L/C^{1/2}$
N =	Panel loading across section width, lb/in.
P =	Applied load, lb
t =	Thickness of section element, in.
t_e =	Effective thickness of wide panel based on total area (skin and stiffener) across panel width, sq in./in.
t_s =	Skin thickness, in.
η_c =	Plasticity correction factor for plate buckling
η_t =	Column modulus-reduction coefficient $= E_t/E$
ρ =	Radius of gyration of column section, in.
σ =	Applied stress, psi
σ_{col} =	Euler or primary column allowable stress, psi
σ_{cr} =	Initial buckling (or crippling) stress of a section element, psi

on the section. For a specific material, the only quantities which the designer can control are the shape factor and the support spacing.

The column section should be designed so that each element of the section has the same buckling or crippling stress, where this stress is made equal to the primary column allowable stress.

From Equation 1, shape factor k_{sx} for a column is

$$k_{sx} = \frac{\rho^2}{A\,\frac{b}{t}} = \frac{I}{A^2\,\frac{b}{t}} \qquad (2)$$

For a wide panel, Equation 1 becomes:

$$\sigma^4 = \pi^2 K_c \left(\frac{\rho}{t_e}\,\frac{t_e}{b}\right)^2 (\eta_t \eta_c E^2) \left(\frac{N}{L'}\right)^2 \qquad (3)$$

where the shape factor now is

$$k_{ss} = \frac{\rho}{t_e}\,\frac{t_e}{b} \qquad (4)$$

and t_e is skin thickness, or the local thickness of an element. The shape factor is nondimensional in each situation.

Shape-Factor Calculations: Consider the I-section shown in Fig. 1. To find the optimum proportions of this section, the initial buckling or crippling stress of all the elements will be made equal to the primary column allowable stress. Each half-flange element is considered to have one edge free and one edge simply supported. Both edges of the web are considered to be simply supported.

For the web,

$$\sigma_{cr} = 3.6\,\eta_c E \left(\frac{t}{b}\right)^2$$

and for the half-flange,[4]

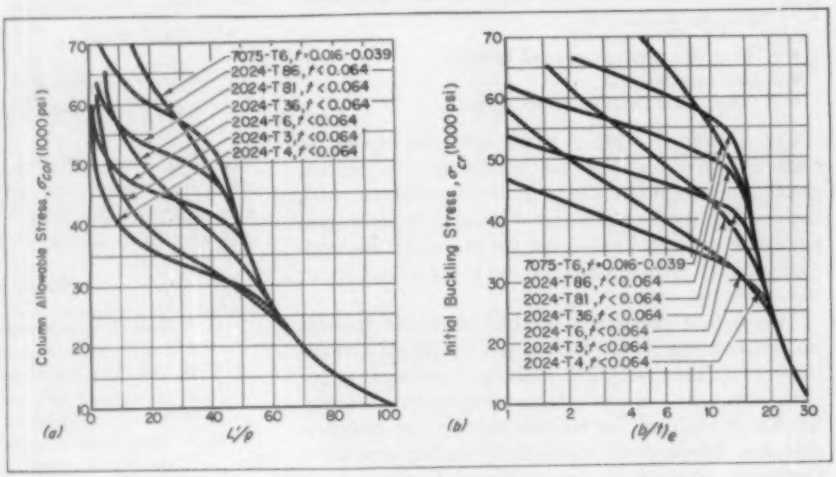


Fig. 2—Typical plots of, *a*, column allowable stress and, *b*, initial buckling stress for columns made of 2024 and 7075 clad aluminum-alloy sheet and loaded in compression. In the chart at *b* for initial buckling stress, $(b/t) = (K)^{1/2}(b/t)_e$ where K is the buckling constant which is a function of edge restraint. For a simply supported sheet element in compression, $(K)^{1/2} = 1.9$. Note that the webs of I-beams and channels are both examples of elements that are simply supported on four sides, and have this value of K. The flanges of these members have one edge free, but the width of the member is modified to give the same buckling stress as the web.

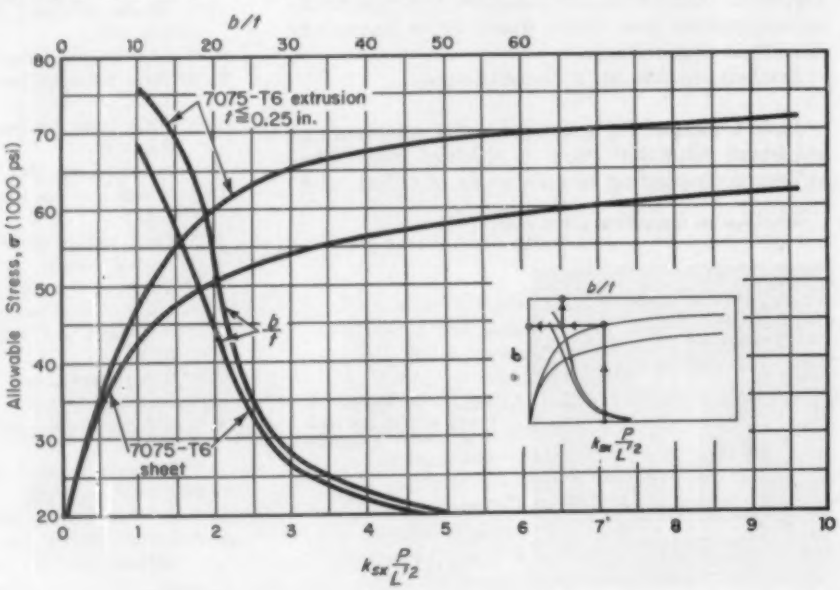


Fig. 3—Optimum-design curves for 7075-T6 aluminum-alloy extrusion and 7075-T6 aluminum-alloy sheet.

$$\sigma_{cr} = (0.615)^2 \eta_c E \left(\frac{t}{w'} \right)^2$$

Setting these two expressions equal and solving,

$$w' = \frac{0.615}{(3.6)^{1/2}} b = 0.324\, b$$

and $w = 2w' = 0.648\, b$. Then,

$$A = (2w + b)t = 2.296\, bt$$

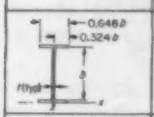
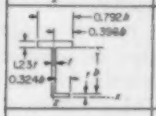
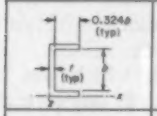
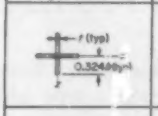
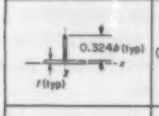
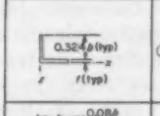
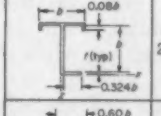
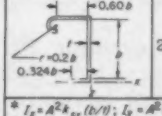
$$I = \left(2wt + \frac{bt}{3} \right) \frac{b^2}{4} = 0.406\, b^3 t$$

From Equation 2, which is based on $\sigma_{cr} = \sigma_{col}$

$$k_{ss} = \frac{0.406\, b^3 t}{(2.296\, bt)^2 \dfrac{b}{t}} = 0.0775$$

Thus, the shape factor has a specific numerical value which is a function of the shape of the section but is independent of b, t, load, and material properties. The allowable stress is proportional to the value of this factor. Shape factors for various section configurations are given in Table. 1. For preliminary work, k_{ss}' values in Table 1 give the shape factor for lateral instability of the outstanding flange.

Table 1 - Shape Factors for Column Sections*

Section	A	$\bar{y}$	$\bar{x}$	k_{sx}	k_{sz}	k_{ss}' †
	2.296 bt	0.5 b	0	0.0775	0.0079	0.024
	2.296 bt	0.64 b	0.023 b	0.070	0.0116	0.028
	1.648 bt	0.5 b	0.064 b	0.090	0.0059	0.0117
	1.296 bt	0	0	0.0135	0.0135	. . .
	0.972 bt	0.056 b	0	0.0095	0.024	. . .
	0.648 bt	0.084 b	0.084 b	0.0174	0.0174	. . .
	2.484 bt	0.667 b	0.021 b	0.0623	0.0216	0.045
	2.552 bt	0.628 b	0.262 b	0.0504	0.0315	0.051

* $I_x = A^2 k_{sx}\,(b/t)$; $I_y = A^2 k_{sz}\,(b/t)$

† Based on short flange supported by skin, and computed from section properties for all material above 0.5 of vertical height ($b/2$).

Optimum-Design Curves: To plot optimum-design curves, the following expressions are more convenient forms of Equations 1 and 3. For columns,

$$\sigma = \frac{P}{A} = \frac{P}{L'^2} \left(\frac{\rho^2}{A \dfrac{b}{t}} \right) \frac{b}{t} \left(\frac{L'}{\rho} \right)^2$$

$$= k_{sx} \frac{P}{L'^2} \frac{b}{t} \left(\frac{L'}{\rho} \right)^2 \qquad (5)$$

and for wide panels

$$\sigma = \frac{N}{L'} \left(\frac{\rho}{t_s} \frac{t_s}{b} \right) \frac{b}{t} \frac{L'}{\rho} = k_{sx} \frac{N}{L'} \frac{b}{t} \frac{L'}{\rho} \qquad (6)$$

Note that these expressions contain the shape factor, a loading term, and geometric factors (b/t and L'/ρ) against which the column allowable stress and crippling stresses are generally plotted. Thus, by using the following procedure, optimum design curves for a given material can be constructed:

1. Assume a value of stress σ.
2. Determine the values of L'/ρ and b/t, corresponding to assumed values of σ, from curves for column allowable stress and crippling stresses. A number of such curves have been developed, Fig. 2. Similar plots are also readily available for other materials.[5,6]
3. Solve for $k_{sx}\,(P/L'^2)$ from Equation 5, or $k_{sx}\,(N/L')$ from Equation 6.

Optimum design curves, which were plotted by this procedure, for 7075-T6 aluminum-alloy extrusion and sheet are given in Fig. 3.

Design Example: A simply supported (pin-ended) column is to be made of 7075-T6 extruded aluminum-alloy channel. The column is subjected to a compression load of 10,000 lb and is 20 in. long. Determine the optimum dimensions of the minimum-area section required.

By definition, $L' = 20/(1)^{1/2} = 20$ in. From Table 1, $k_{ss} = 0.090$ which gives $k_{sx}(P/L'^2) = 0.090\ (10{,}000/400) = 2.25$. From Fig. 3, $\sigma = 61{,}500$ psi and $b/t = 18.5$. By definition, $A = P/\sigma = 10{,}000/61{,}500 = 0.162$ sq in. Also, from Table 1, $A = 1.648\ bt$. Therefore,

$$1.648\, b \left(\frac{b}{18.5} \right) = 0.089\, b^2 = 0.162 \text{ sq in.}$$

and $b = (0.162/0.089)^{1/2} = 1.35$ in. which gives $t = 1.35/18.5 = 0.073$ in.

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Additives in Lubricants

- What they are
- How they work
- Where they are used

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Research and Development Dept.
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Detroit, Mich.

TIME and again, specially compounded lubricants have helped to solve mechanical problems involving limitations on space, weight, and cost. These tailor-made lubricants have been made possible by the growing number of lubricant additives.

As defined here, additives are chemical compounds which improve some properties of a product, or impart new characteristics to it. Lubricant additives fall into two general classes:

1. Those that affect some physical characteristics of the lubricant, such as pour point, foaming, and viscosity index.
2. Those whose end effect is more chemical in nature, and usually more measurable in terms of some performance characteristic. Examples are oxidation-corrosion inhibitors, detergents and dispersants, and extreme-pressure and antiwear agents.

Compounding of lubricants with additives is very complex. Many hundreds of chemical compounds have been found to enhance or impart some individual property to a lubricant. However, the fact that these compounds must be compatible with other chemical agents, as well as with the base lubricant, greatly reduces the number of usable ones. Pertinent information on commonly used lubricant additives is summarized in Table 1. Remarks which follow elaborate on the table data.

Oxidation - Corrosion Inhibitors: Oxidation inhibitors may react in two different ways. One type functions as a chain-breaking agent by reacting with the material formed in the propagation step to form stable products which will not react further. The other type of inhibitor tends to passivate the metal or metal ions so that they no longer have a catalytic effect on oxidation. Additives in the first group are considered as true antioxidants. Additives in the second group are considered as catalyst poisons.

Oil oxidation depends on five factors: 1. Temperature. 2. Time. 3. Catalysts. 4. Contact with air or oxygen. 5. Lubricant characteristics.

Temperature is probably the one most important factor in oil oxidation. With other conditions constant, the rate of oxidation of hydrocarbons approximately doubles for every 18 to 20 F increase in temperature.

Time also influences the selection of oxidation inhibitors. The higher the temperature the shorter the time a lubricant will remain in a usable state.

It is generally known that some metals have a catalytic effect on oil oxidation. The rate of oxidation, especially at higher temperature, is increased considerably by the presence of metals. Also, different metals and combinations of metals have different catalytic effects. Thus, the metals with which the lubricant will contact in service must be considered.

Detergent-Dispersants: Some detergent - dispersant - type additive agents are more effective than others at high temperatures with oxidation products formed at these high temperatures.

In addition to their main intended function—engine cleanliness—certain detergent-dispersant-type additives also affect other properties of a lubricant. Some of these effects are beneficial, such as improved rust protection, while others are undesirable, such as increased tendency to foam and emulsify.

Oiliness, Film-Strength, EP, and Antiwear Agents: Under hydrodynamic (thick film) lubrication conditions, no special additive agent is needed. However, under boundary

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Table 1—Commonly Used Lubricant Additives

Type of Additive	Types of Compounds	Reasons for Use	Mechanism of Action
Antioxidants or oxidation inhibitors	Organic compounds containing sulfur, phosphorus, or nitrogen, such as organic amines, sulfides, hydroxy sulfides, phenols. Metals like tin, zinc or barium are often incorporated.	To prevent varnish and sludge formation on metal parts; to prevent corrosion of alloy bearings.	Decreases amount of oxygen taken up by the oil thereby reducing formation of acidic bodies. Terminates oil oxidation reactions by formation of inactive soluble compounds or by taking up oxygen. Additive may be oxidized in preference to oil.
Anticorrosives, corrosion preventives, or catalyst "poisons"	Organic compounds containing active sulfur, phosphorus, or nitrogen, such as organic sulfides, phosphites, metal salts of thiophosphoric acid, and sulfurized waxes.	To prevent failure of alloy bearings by corrosive action; to prevent corrosive attack on other metal surfaces.	Inhibits oxidation so that no acidic bodies are formed, or enables a protective film to form on bearings or other metal surfaces. Chemical film formation on metal surfaces decreases catalytic oxidation of the oil.
Detergents	Metallo-organic compounds such as phosphates, phenolates, sulfonates, alcoholates; high molecular weight soaps containing metals like magnesium, barium, calcium, tin.	To keep metal surfaces clean and prevent deposit formation of all types.	By chemical reaction or oxidation direction, oil-soluble oxidation products are prevented from becoming insoluble and depositing on various engine parts.
Dispersants	Metallo-organic compounds such as naphthenates and sulfonates; organic salts containing metals, like calcium, cobalt, and strontium; nonmetal polymeric dispersant compounds.	To keep potential insolubles in suspension, thus to prevent their depositing on metal parts.	Deposition of fuel soot and insoluble oil decomposition products is prevented by breakdown into finely divided state. In colloidal form, contaminating particles remain suspended in oil.
Oiliness, film-strength, extreme-pressure, and antiwear agents	Organic compounds containing chlorine, phosphorus, and sulfur such as chlorinated waxes, organic phosphates and phosphites, and lead soaps.	To reduce friction; to prevent galling, scoring and seizure; to reduce wear.	By chemical reaction, film is formed on metal contacting surfaces which has lower shear strength than base metal thereby reducing friction and preventing welding and seizure of contacting surfaces when oil film is ruptured.
Rust preventives	Sulfonates, amines, fatty oils, and certain fatty acids, oxidized wax acids, phosphates, halogenated derivatives of certain fatty acids.	To prevent rust of metal parts during shutdown periods, storage, or shipment.	Preferential adsorption of polar-type surface-active materials on metal surface. This film repels attack of water. Neutralizing corrosive acids.
Metal deactivators	Complex organic nitrogen and sulfur-containing compounds such as certain complex amines and sulfides. Some soaps.	Pacify, prevent, or counteract catalytic effect of metals on oxidation.	Form inactive protective film by physical or chemical adsorption or absorption. Form catalytically inactive complex with soluble or insoluble metal ions.
Stringiness and tackiness agents	Certain high-molecular-weight polymers and aluminum soaps of unsaturated fatty acids.	Increases adhesiveness of lubricant on metal surfaces; form protective coating.	Increases viscosity of lubricant.
Water repellents	Organosilicon and other polymers, certain higher aliphatic amines and hydroxy fatty acids.	Provide water repellent or resistant properties to non-soap thickened greases and other lubricants.	Surface-active agents form protective film on grease thickeners or other components of lubricants to reduce their affinity for water.
Emulsifiers	Certain soaps of fats and fatty acids, sulfonic acids or naphthenic acids.	Used to emulsify soluble oils with water to give coolant lubricant type fluid.	Surface-active chemical agents reduce interfacial tensions so oil can be finely dispersed in water.
Dyes	Oil soluble organic compounds with high coloring power.	Provide distinctive or attractive color.	The organic compounds with high coloring power (dyes) dissolve to impart color.
Color stabilizers	Certain hydroquinones, dithiocarbamates, aliphatic amines, dicyclohexylamines.	Stabilize color and prevent formation of undesirable color.	Certain chemicals can destroy color-forming bodies by stopping or changing chemical reaction. Sometimes accomplished by oxidation inhibitors functioning as indicated above.
Odor control agents	Certain oil soluble synthetic perfumes, sometimes nitro benzol.	To provide distinctive or pleasant odor or mask undesirable odors.	Small amounts of highly odoriferous substances impart fragrant or pleasant odor when mixed with lubricants.
Antiseptics (bactericide or disinfectant)	Certain alcohols, aldehydes, phenols, mercuric compounds, and chlorine containing compounds.	To control odor, foaming, metal staining, emulsion breaking in emulsion type lubricants.	Used in soluble oils to reduce or prevent growth of bacteria causing deleterious effects in emulsion lubricants.
Pour-point depressants	Wax alkylated naphthalene or phenol and their polymers; methacrylate polymers.	To lower pour point of lubricating oils.	Wax crystals in oils coated to prevent growth and oil absorption at reduced temperatures.
Viscosity-index improvers	Polymerized olefins or iso-olefins; butylene polymers, methacrylic acid ester polymers, alkylated styrene polymers.	To lower rate of change of viscosity with temperature.	Improvers are less affected by temperature change than oil. They raise viscosity at 200 F more in proportion than at 100 F due to their change in solubilities.
Foam inhibitors	Silicone polymers.	To prevent formation of stable foam.	Reduces interfacial tension so small air bubbles can combine to form larger bubbles that separate faster.

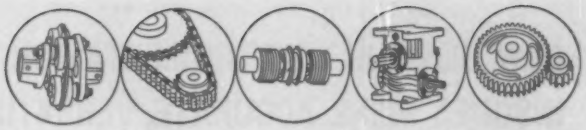
lubrication conditions, they are required. Since boundary friction is a surface phenomenon, the lubricating ability of an oil blend may be changed by the use of small amounts of some types of surface-active agents. These agents may function by either a chemical or physical adsorption mechanism, depending on whether they react with the bearing metal.

EP (extreme-pressure) additives are sometimes considered misnamed since high temperatures, rather than high loads, in a bearing system are required for their effective functioning. In some systems, localized temperatures of up to 1000 F occur.

A distinction between EP and antiwear agents is based on the mechanism by which they function. Antiwear agents are thought to function through a chemical polishing action which can take place at relatively low temperatures.

Rust Preventives: The problem of rust, although chemically an oxidation process, is distinguished here from high-temperature oxidation as encountered in engines. The rusting referred to occurs on ferrous parts in the presence of contaminants, such as water or acidic materials, resulting from fuel or oil oxidation. Although straight petroleum oils have some rust protective properties, they are inadequate under severe conditions.

Stringiness or Tackiness Agents: These materials are rather limited



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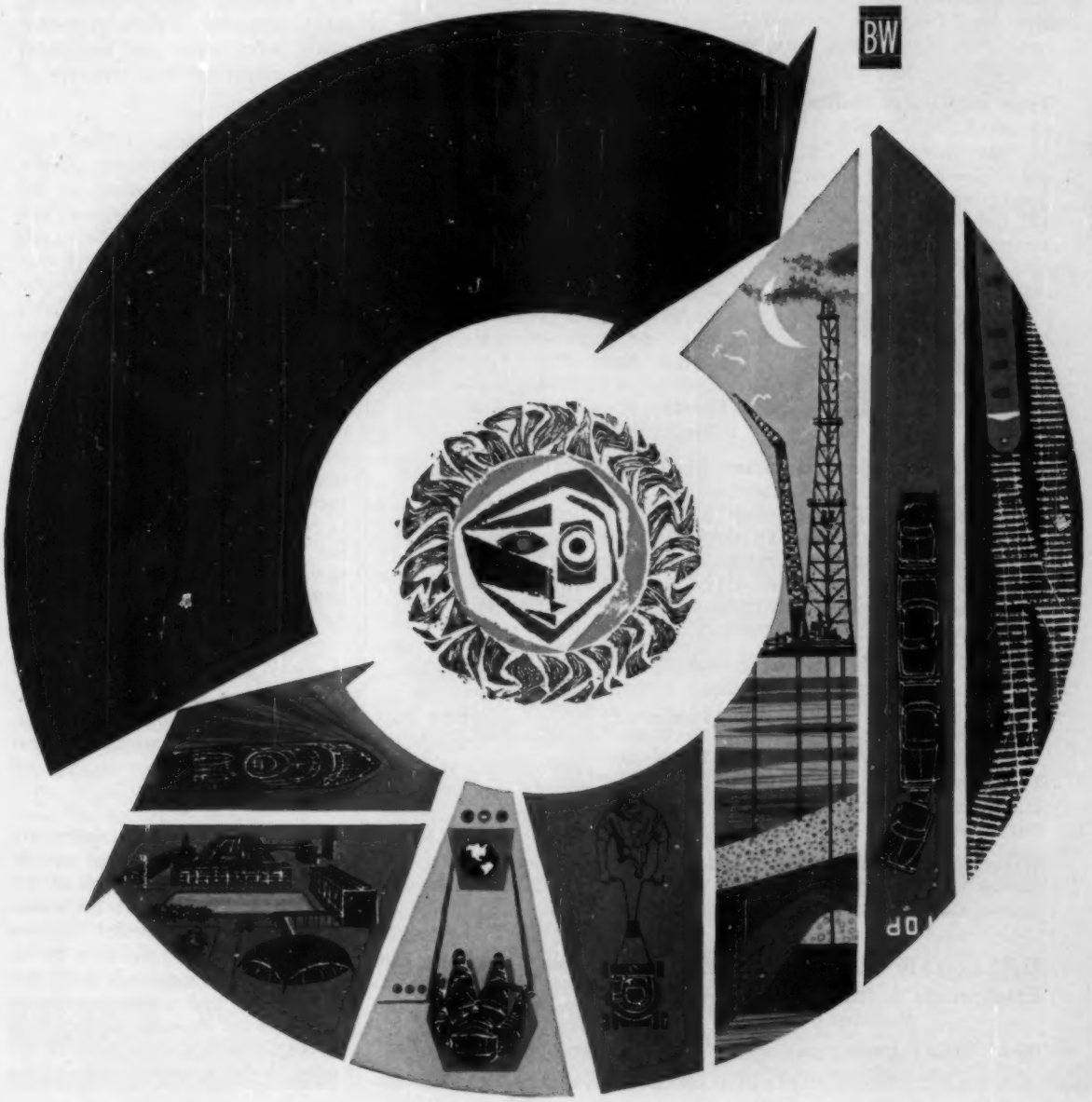

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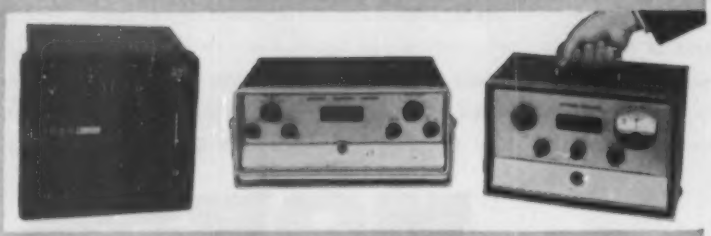

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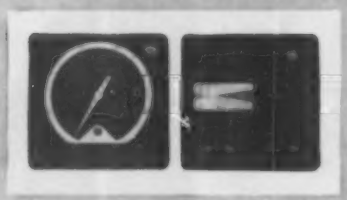

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in their application, partly because of their limited stability under high temperatures (over 2000 F) and under conditions of high shear.

Emulsifiers: In most lubrication applications, emulsification is undesirable. However, there are certain uses where emulsification is an important characteristic. These are in the so-called soluble oils used as coolants and lubricants for various metal cutting and grinding operations.

Dyes: In some applications, it is desirable to have a distinctive color for a lubricant, mainly for identification purposes. This is important when leaks occur on equipment which uses more than one type of lubricant.

Antiseptic Agents: It has been found that different types of bacteria can form, depending on the particular conditions involved, and that different chemical compounds are required for their effective control. Experience has shown that some bacteria, although controllable initially by a given bactericide, tend to build up an immunity.

Viscosity-Index Improvers: The molecules of a VI improver in an oil solvent have the property of increasing in size with increasing temperature, and hence contribute more to raising viscosity at high than at low temperatures. At low temperature, most of the material is in colloidal suspension, and has little effect on viscosity.

There are great differences in the shear stability and effectiveness of VI improvers. Generally, the greater the concentration of improver, the greater the amount of shear down that can occur in the oil blend.

Balanced Additive Combinations: Perhaps the one factor that complicates most the development of additive-type lubricants is the necessity for a well-balanced additive combination. It is common for lubricants to contain additives that affect two, and sometimes ten or more, of its characteristics. Considerable testing is required to determine the optimum concentration

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of a single additive material, both from the standpoint of performance and cost.

SAE Paper No. 397B, "Additives in Lubricants," presented at the Heavy-Duty Vehicle Meeting, Milwaukee, Sept., 1961, 7 pp.

techniques

Design Guides for Lightweight Steel Castings

S. A. McCarthy, senior product design engineer, McDonnell Aircraft Corp., St. Louis, Mo.

Integrated design and production considerations for precision-quality steel castings.

To produce the best possible casting having smooth as-cast surfaces, with minimum weight and cost, seven rules-of-thumb should be kept in mind in design:

1. Induce progressive solidification by tapering or gradually decreasing adjoining sections as the distance from the largest center or centers of mass become greater. This is to induce x-ray soundness in the junctions and surfaces.

2. Avoid isolated heavy sections in thin walls which cannot be gated easily or fed by separate risers.

3. Do not add excessive clean-up stock on functional surfaces. This will vary from 0.015 in. to 0.030 in. on castings one to 3 in. in their maximum dimensions, to 0.090 in. to 0.125 in. on larger castings.

4. Avoid excessive fillet sections which cannot be fed. Otherwise, a centerline-type porosity will result. Sharp corners (1/64-in. radius or less) will cause cracks and surface shrinkage.

5. Use gussets, ribs, and minor corrugations to reinforce plain, flat surfaces or unbroken, gradually curved surfaces. Without these reinforcements, distortion in processing may occur.

6. Hold wall thicknesses to a minimum of 0.12 in. on small castings. However, 0.60 in. to 0.090 in. can be held if possible to be fed by adjacent heavy sections.

7. Avoid small holes 3/16-in. diameter or less, and blind holes with depth in excess of twice their di-

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Circle 305 on Page 19

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ameter. Cast threads are practical in the ferrous alloys, providing Class 2 threads are acceptable.

"Aircraft—Missile Steel Castings," presented at the 65th AFS Casting Congress, San Francisco, May, 1961, 5 pp.

Application of Digital Control

E. P. Ross and F. G. Willard, Systems Control Dept., Westinghouse Electric Corp., Buffalo, N. Y.

Review of digital control technique, and description of four static digital control systems currently in operation.

The review covers basic digital control functions, instrumentation, information input and storage, logic and sequencing, the arithmetic function, digital regulation, and information output.

"Application of Digital Control," presented at the Westinghouse Electric Corp. Computer Symposium, New York, July, 1961, 16 pp.

materials

Effects of Radiation on Materials and Equipment

Mary Jane Oestmann and J. F. Kircher, Battelle Memorial Institute, Columbus, Ohio

Nuclear radiation considered as an environmental factor in product design.

Two types of radiation effects are recognized: Transient and permanent. Transient effects disappear when irradiation ceases. This paper is concerned with permanent effects.

Factors which contribute to the adverse effects of radiation include: Extreme temperatures, oxidizing atmospheres, and mechanical degradation. The extent of radiation damage is influenced by: Composition of the irradiated materials, certain nonradiation environmental conditions, the type of radiation, the dose of radiation, and the dose rate.

The effects of radiation on particular properties of metals are:

Yield Strength: Increases up to several hundred per cent in annealed materials and to a lesser extent in previously cold-worked or heat-treated metals.

Tensile Strength: Increases up to 75 per cent for annealed materials and to

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Circle 307 on Page 19

a lesser extent in cold-worked metals.

Ductility: Decreases by 1/5 to 1/3 for annealed materials and to a lesser extent for cold-worked metals.

Elastic Constant: Limited data indicate little or no change.

Creep Rate: Usually unaffected.

Work Hardening: Decreases.

Impact Strength: Decreases—ductile to brittle transition temperature raised by as much as 212 F.

Fatigue Strength: Limited data indicate no effect.

Hardness: Increases moderately, less than 100 Brinell.

Damping Capacity: No change.

Density: Decreases by as much as 0.2 per cent; can be considerable when gas formation occurs.

Diffusion Coefficient: Limited data show slight increase.

Electrical Resistivity: Increases by less than 10 per cent at room temperature.

Phase Changes: Possible in certain systems.

Microstructure: Changes observed in certain systems under selected conditions.

Thermoelectric Emf: Little change.

Thermoconductivity: Limited data show moderate decrease.

Corrosion Resistance: Little or no change.

Induced Radiation: Depends on concentration and cross section of components; cobalt containing alloys are undesirable.

Dimensional Stability: Moderately affected except where induced radiation has occurred.

Internal Friction: Limited data show little or no effect.

SAE Paper No. 339B, "Radiation Effects on Materials and Equipment," presented at the National Aeronautic Meeting, New York, April, 1961, 13 *pp.*

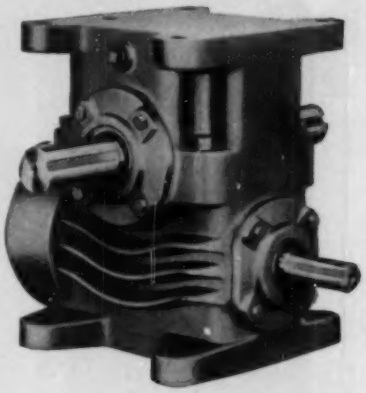
High-Temperature Oxidation Of Aluminum-Magnesium Alloys

R. A. Hine and R. D. Guminski, Chemistry Div. of Aluminum Laboratories Ltd., England

Oxidation of aluminum-magnesium alloys in dry and undried air and in other gases, in the range 440 to 540 C.

In dry air a parabolic rate law that quickly transforms to a linear law is followed, but in undried air different kinetics are observed. Up to 200 hr, the over-all rate of oxidation is reduced, but blisters form on the surface after 90 hr and from that point onward the rate increases.

A Morse answer



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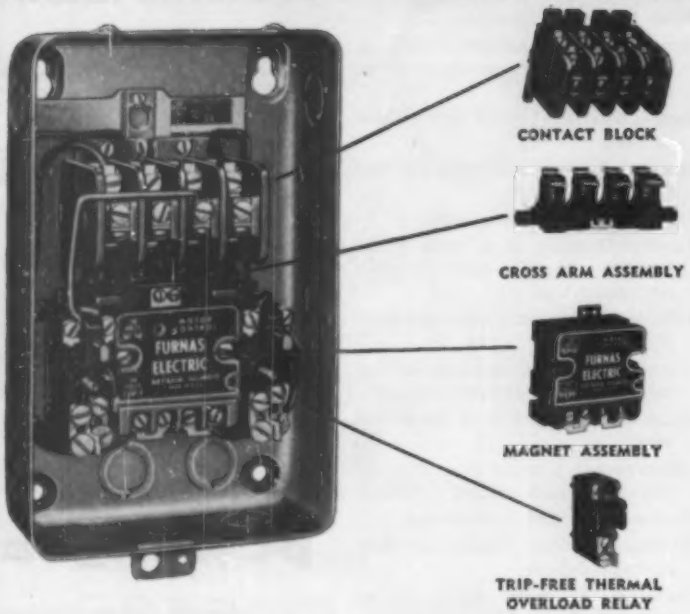

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Analysis shows that, in all cases, the oxide becomes progressively enriched in magnesia as oxidation proceeds, and the curve of magnesia concentration follows closely the oxidation curve. At the same time, the outer layer of alloy becomes denuded of magnesium.

Institute of Metals Paper No. 2077, "High-Temperature Oxidation of Aluminum-Magnesium Alloys in Various Gaseous Atmospheres." Journal of the Institute of Metals, Vol. 89, 1960-61, pp. 417 to 422.

Lightweight Cellular Metal

L. Polansky and S. Lipson, metallurgists, and H. Markus, director, Metallurgical Research Laboratory, Frankford Arsenal, Philadelphia, Pa.

Description and application of a process for the production of cellular metals.

The process consists of preparing a refractory mold, filling the mold with soluble granules which correspond to the size and shape of the pores desired in the metal, and infiltrating the molten metal into this soluble aggregate. After leeching with a suitable solvent, the metal has a void structure of interconnecting cells which correspond to the shape and size of the soluble aggregate. The apparent density of the metal body can be controlled from a maximum of approximately one-third of its base density to some lower density in the order of one-fifth the base density.

In addition to process development, which includes casting of shapes as well as billets, a limited investigation of the mechanical characteristics of aluminum-base cellular metal is reported.

"Lightweight Cellular Metal," presented at the 65th AFS Castings Congress, San Francisco, May, 1961, 14 pp.

Structure and Hardness of Electrodeposited Chromium

C. P. Brittain, A.E.I. Birlec Ltd.; and G. C. Smith, Dept. of Metallurgy, University of Cambridge, England

Certain properties of chromium electrodeposited at temperatures between 45 and 85 C and annealed up to 1050 C.

As-deposited structures are difficult to interpret, but indications are that grain size increases with rise in deposition temperature. It is sug-

gested that grain size may be the main factor controlling the hardness of chromium deposits.

Institute of Metals Paper No. 2076, "The Structure and Hardness of Electrodeposited Chromium," Journal of the Institute of Metals, Vol. 89, 1960-61, pp. 407 to 416.

management

Bibliography on Reproduction Of Documentary Information

Loretta J. Kiersky, librarian, Central Research Laboratories, Air Reduction Co., Murray Hill, N. J.

Compilation of literature on microfilming, from 1955 to 1960.

References provided here are readily available. Bibliography subheadings are: General, copy methods and processes, equipment, applications, systems, and standards.

"Bibliography on Reproduction of Documentary Information," presented at the Tenth Annual Convention of the National Microfilm Association, Chicago, April, 1961, Proceedings pp. 117 to 134.

electrical

Applications of Radioactivity To Electronics

Alfred J. Moses, Hazleton-Nuclear Science Corp., Palo Alto, Calif.

Properties and detection of radioisotopes, and specific applications of radioisotopes to electronics. 1. Ionization of gas. 2. Scintillations of light due to the interaction of particles or radiation with a phosphor. 3. Blackening of photographic film.

WESCON Paper No. 35/2, "A Survey of Applications of Radioactivity to Electronics," presented at the 1961 Western Show and Convention, San Francisco, August, 1961, 3 pp.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to:

AFS — American Foundrymen's Society, Golf and Wolf Rds., Des Plaines, Ill.

Institute of Metals, 17 Belgrave Square, London S.W. 1, England.

National Microfilm Association, P. O. Box 386, Annapolis, Md.

SAE—Society of Automotive Engineers, 485 Lexington Ave., New York 17, N. Y.

WESCON—Western Electronic Show and Convention c/o Institute of Radio Engineers, 1 East 79th St., New York 21, N. Y.

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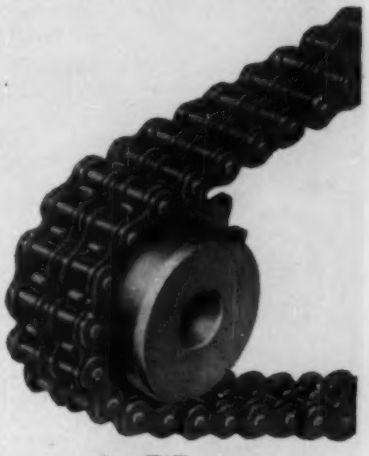

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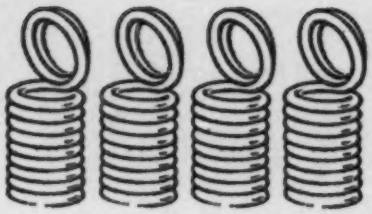

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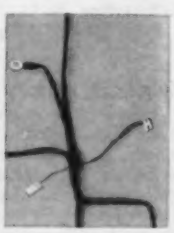

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Helpful Literature for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Transfer Switches, Timers

Covers line of automatic transfer switches, magnetic contactors, special electromagnetic controls, and timing devices for a wide range of applications. Includes specification data and prices. Bulletin A-17, 4 pages. Zenith Electric Co., Dept. MD-1, 152 W. Walton St., Chicago 10, Ill.

Circle 601 on Page 19

One-Piece Fasteners

Presents line of Speed Nut fasteners; parallels each fastening principle employed in the product line with applications and engineering data. Bulletin also includes a section devoted to multiple-function fasteners, presented in case-history style. Bulletin 359, 32 pages. Tinnerman Products Inc., Dept. 14, P. O. Box 6688, Cleveland 1, Ohio.

Circle 602 on Page 19

Solid Lubricants

Discusses in detail the theory and use of solid lubricants. Covers barriers to effective lubrication and describes how solid lubricants can overcome them. Properties of molybdenum disulfide as a dry-film lubricant are presented in detail. Actual applications describe how solid lubricants have solved difficult lubrication problems. Bulletin 132, 8 pages. Alpha-Molykote Corp., 65 Harvard Ave., Stamford, Conn.

Circle 603 on Page 19

Ball Valves

Provides detailed information on manually and pneumatically operated ball valves in sizes from ¼ through 12 in. Covers screwed, socket-weld, and flanged-end models for temperatures from −150 to +100 F, pressures to 1000 psig, and vacuum to 10^{-6} mm Hg. Details two basic types of valves: McCannaseal and McCannaflo. Lists standard body and seat materials. Includes dimensions and weights, material specifications, typical C_v values, and pressure-temperature rating charts. Catalog 1200-A. 32 pages. Hills-McCanna Co., 400 Maple Ave., Carpentersville, Ill.

Circle 604 on Page 19

Electrical Components

Folder contains illustrated sheets covering four major electrical and electronic-component types: Luxolene epoxy-molded coils, miniature coils, conventional coils, and high-voltage power packs. 12 pages. Wabash Magnetics Inc., Wabash, Ind.

Circle 605 on Page 19

Aluminum Boxes and Covers

Describes new aluminum boxes and covers available from stock for packaging electronic components or instruments. Sizes range from 1⅝ in. wide x 3⅜ in. long to 28½ x 28¼ in. in a variety of alloys and gage thicknesses. Also covers round aluminum boxes and covers. Supplement/Catalog B60, 8 pages. Zero Mfg. Co., 1121 Chestnut St., Burbank, Calif.

Circle 606 on Page 19

Plastic Balls

Contains technical information and specifications for plastic balls. Shows physical characteristics, tolerances, and typical applications for seamless balls of six different plastic materials. Also describes some of the modifications in balls that can be made. 4 pages. Ace Plastic Co., 91-30 Van Wyck Expressway, Jamaica 35, N. Y.

Circle 607 on Page 19

Relays, Timer Products

Covers various types of relays available, listing uses, dimensions, and specifications. Also covers standard enclosures to fit the relays. Lists a variety of timer products, including time switches, manual and automatic-reset interval timers, delay timers, and combination units. 64 pages. Telex/Aemco, Div., Telex Inc., 10 State St., Mankato, Minn.

Circle 608 on Page 19

Polycarbonate Resin

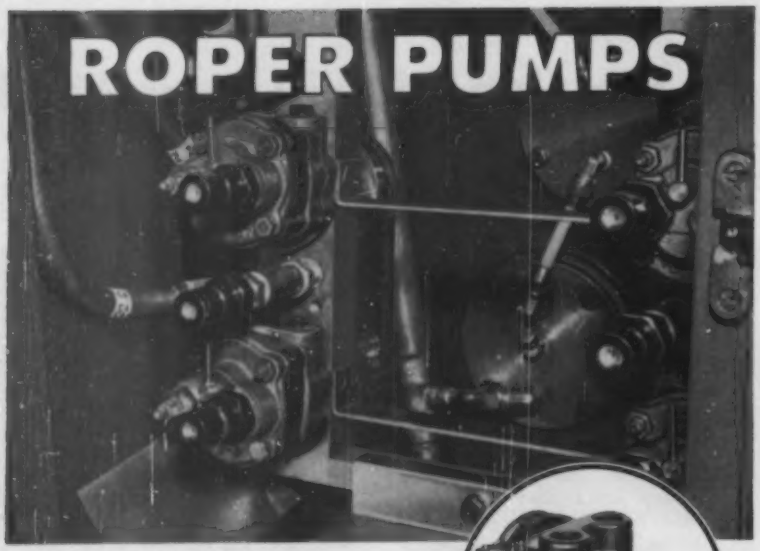
Discusses advantages of Lexan polycarbonate resin for electrical and electronic components. Gives technical data on electrical properties, details physical properties, and describes typical applications. Bulletin CDC-397, 6 pages. Chemical Materials Dept., General Electric Co., Pittsfield, Mass.

Circle 609 on Page 19

Electromagnetic Disc Brake

Covers Series 87,000 Auto-Adjust brakes which mechanically and automatically readjust themselves to compensate for lining wear. Gives drawings and specifications for both standard and dust-tight, waterproof enclosures. Bulletin N.P.P. 3-61-B, 4 pages. Stearns Electric Corp., 120 Broadway, Milwaukee 2, Wis.

Circle 610 on Page 19



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SERIES K FIGURE 17K3

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Circle 313 on Page 19

Constant-Force Springs

Data sheets give detailed design information on Neg'ator constant-force extension springs. Includes a step-by-step procedure for designing these springs, along with fourteen design tables. Other data include descriptions of load-deflection and size-load-life characteristics, mounting considerations, and application limitations. Data Book Section 6, 10 pages. Hunter Spring Co., Div., American Machine & Metals Inc., Lansdale, Pa.

Circle 611 on Page 19

Hydraulic Motors

Provides data on variable-displacement hydraulic motors, fixed-angle, axial-piston units which serve as sources of power for ac generators, fuel boost pumps, turbine starters, and compressors. Bulletin A-5238 describes the principle of operation, and covers performance from the standpoint of efficiency and control accuracy. Aero Hydraulics Div., Vickers Inc., Sperry-Rand Corp., Detroit 32, Mich.

Circle 612 on Page 19

Synthetic Fiber Felts

Describes synthetic fiber felts of polypropylene, Teflon, Dacron, Dynel, rayon viscose, Orlon, and nylon, available in several types of material constructions ranging from pad types to high-density filter fabrics. Includes a general description and typical uses for six categories of Feutron constructions. Technical Bulletin 4-61, 8 pages. American Felt Co., 2 Glenville Rd., Glenville, Conn.

Circle 613 on Page 19

O-Ring Seals

Explains in simple terms and drawings how the O-ring works, how the seal reacts to pressure, and reason for the configuration. O-ring sample is attached for demonstration. Bulletin 1-065, 6 pages. Seals-East Orange Inc., 393 Central Ave., East Orange, N. J.

Circle 614 on Page 19

Synchros, Rotary Components

Presents data on synchro shafts, synchro conventions, synchros of various sizes, resolvers, linear transformers, servo motor, generators, tachometers, dc motors, gear-train packages, brakes, and clutches. Includes four pages of servo motor, generator, and tachometer performance curves. 40 pages. Clifton Precision Products Co. Inc., Clifton Heights, Pa.

Circle 615 on Page 19

Electro-Optical Component

Describes applications of Raysistor electro-optical component, which consists of a light bulb and a photocell assembled at opposite ends of a lightproof casing. Also describes operation, electrical characteristics, and factors affecting parameters. Technical Bulletin 163-I, 12 pages. Industrial Components Div., Raytheon Co., 55 Chapel St., Newton 58, Mass.

Circle 616 on Page 19

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Circle 617 on Page 19

Conveyors and Components

Gives design and application data on portable and adjustable conveyors, hinged-steel belt conveyors, and custom conveyors from off-the-shelf components. Engineering data section gives specifications on standard conveyor components for building custom conveyors of all types, and on available types of hinged-steel belting for handling heavy, hot, and rough materials. Catalog MF-100A, 8 pages. May-Fran Mfg. Co., 1710 Clarkstone Rd., Cleveland 12, Ohio.

Circle 618 on Page 19

Metal Structural Material

Lindsay Structure design manual describes this steel structural material which has a high strength-to-weight ratio. Lists applications which show diversity of use, and provides a complete listing and descriptions of all parts and components. Structure is used in the construction of cabinets, housings, enclosures, trucks, and trailers of all sizes and shapes, and needs no tooling, cutting, or welding. 60 pages. International Steel Co., Evansville, Ind.

Circle 619 on Page 19

Air, Hydraulic Cylinders

Contains dimensional data, gives descriptions on stainless-steel body air and hydraulic cylinders in ¾, 1 1/16, and 1½-in. bores. Covers single and double-acting units, built-in manual-valve air cylinders, and three and four-way disc air valves. Bulletin 1260, 10 pages. Bimba Mfg. Co., 101 Main St., Monee, Ill.

Circle 620 on Page 19

Seamless Mylar Belts

Covers use of seamless Mylar belts for precision power transmission. Discusses properties of Mylar and lists design advantages. Gives information on specifications, sizes, and ordering. 4 pages. Kinelogic Corp., 1256 N. Fair Oaks Ave., Pasadena, Calif.

Circle 621 on Page 19

Solid-Cast Stators

Describes solid-cast Everseal encapsulation for the protection of motor windings against severe environmental conditions. Gives the results of tests made on Everseal formulation and on completed solid-cast stators. Bulletin F-2034, 8 pages. U. S. Electrical Motors Inc., P. O. Box 2058 Terminal Annex, Los Angeles 54, Calif.

Circle 622 on Page 19

• tolerances
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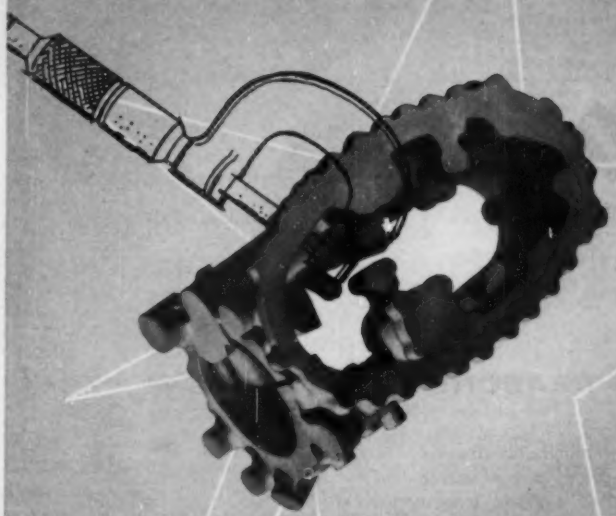


Before now . . . it was thought impossible to cast alloys to dimensional tolerances of ±.005, without expensive machining.

Exclusive Wauke-Sha ceramic molds prevent voids, even with light and heavy adjacent sections, reproduce hairline intricacies without porosity or surface blemish. Only this patented Wauke-Sha process assures:

- intricate parts with no costly machining
- hairline reproduction of detail
- no cracking or tearing
- no porosity, internal voids, cracks
- no surface gas holes, blemishes, inclusions

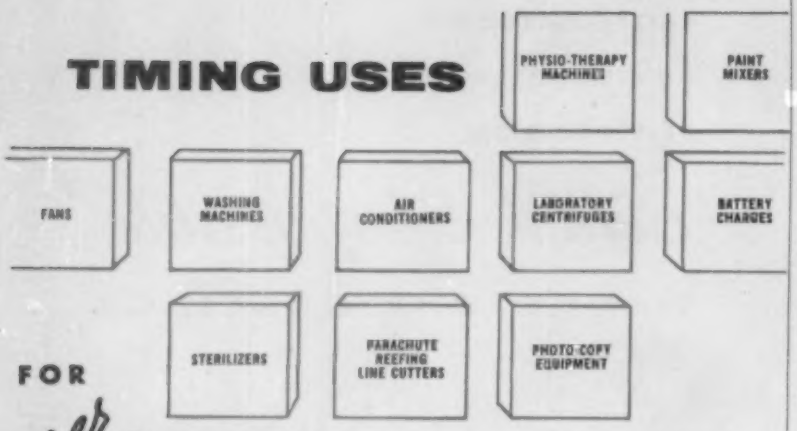
Wauke-Sha castings make possible full design flexibility without limitation on casting size. Every day . . . Wauke-Sha castings are meeting the severe conditions in the nuclear field, where "soundness" is imperative.

Waukesha Foundry Company

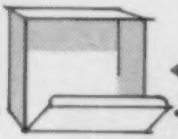
WAUKESHA FOUNDRY CO.
Dept. F-29, Waukesha, Wis.
Manufacturers of corrosion-resistant castings, inclusive of non-galling alloys, Stainless Steel, Waukesha Metal, Monel, Pure Nickel, Inconel, Ni-Resist, plus special Nickel-Chromium Alloys for specific applications.

Circle 314 on Page 19

TIMING USES



FOR *over* 3000 VARIATIONS OF ... "MARK-TIME" TIMING DEVICES



Reserved For Your Timing Problem

4 GOOD REASONS

RELIABILITY
Spring power eliminates dependence on electrical power source. The mainspring is made from a new, super-tough special steel alloy, which virtually eliminates failure, and is UNBREAKABLE.

VERSATILITY
Our timing devices are designed to ring bells, flash lights, turn valves, pull release pins, cut cords, open containers, and start, stop or operate electrical or mechanical equipment.

LOW COST
Many Timers use basically the same parts and components. Thus, slight variations can be produced at quite attractive prices.

SHORT RUNS
A specialty. R & D work welcome.

Write for your copy of our new Catalog.

Missile controls
Clothes dryers
X ray equipment
Lighting equipment
Space heaters
Bulk milk coolers
. . . and many others

M. H. RHODES, Inc.
Hartford 2, Connecticut

In Canada M. H. Rhodes (Canada) Ltd.
Ottawa 5, Ontario

MARK-TIME ®

Circle 315 on Page 19

HELPFUL LITERATURE

Trimmer Capacitors

Gives complete data on glass, plastic, and ceramic capacitors. Emphasizes new glass trimmer capacitors which operate from −55 to +125 C at 100 v dcw. Bulletin 314-3, 16 pages. Erie Electronics Div., Erie Resistor Corp., 644 W. 12th St., Erie, Pa.

Circle 623 on Page 19

Mechanical Differentials

In addition to general information on differentials and design criteria, contains 27 drawings of stock and pre-engineered differentials. Drawings are A-size and printed on perforated pages which can be detached and reproduced or traced for use in conjunction with existing drawings. Covers backlash, breakaway torque, starting torque, and running torque. Brochure 8101, 44 pages. Dynamic Gear Co., 175 Dixon Ave., Amityville, L. I., N. Y.

Circle 624 on Page 19

Hydraulic Rubber Hose

Data on nonskive hydraulic rubber hose includes design and performance data for two basic types—R301 hose, which is a single-wire-reinforced design for medium-pressure service, and R302 hose, a high-pressure design with two layers of wire-braid reinforcement. End fittings include JIC swivel, SAE female swivel, and male pipe terminators. For bulk hose users, catalog describes a field swaging tool suitable for attaching end fittings to Teflon hose as well as the new hydraulic rubber hose. 14 pages. Titeflex Inc., Springfield 4, Mass.

Circle 625 on Page 19

Automatic Data Logger

Data-Master logger performs two basic functions: Systematic collection of process, test, and other operating data; presentation of this data in the most useful form for supervisory, process analysis, research, and accounting purposes, or for direct input into computers. Bulletin points out the application flexibility of the unit, and discusses operating-system installations in manufacturing, distribution, and process industries. Bulletin D401, 4 pages. Bristol Co., Waterbury 20, Conn.

Circle 626 on Page 19

O-Rings

Lists physical properties of stock compounds used in the manufacture of O-rings. Also gives recommended groove dimensions for special size O-ring static seals. 4 pages. Irving B. Moore Corp., 63 High St., Boston 10, Mass.

Circle 627 on Page 19

Plastic Wire Connectors

Discusses plastic wire connectors designed specifically for volume appliance and fixture production. Includes list of advantages, shows how to select the units, and includes material on other products. Form J-240, 4 pages. Ideal Industries Inc., Sycamore, Ill.

Circle 628 on Page 19

Hollow Aluminum Stock

Details material cost savings of 10 to 26 per cent when aluminum hollow screw-machine stock and mechanical tube are used in preference to solid stock. Tabular data outline machinability and corrosion-resistance ratings, mechanical properties and specifications of the various alloys, and range of sizes and alloys offered. "The Hole Story," 12 pages. Aluminum Co. of America, 731 Alcoa Bldg., Pittsburgh 19, Pa.

Circle 629 on Page 19

Remote Valve Control

New design manual covers manual remote controls for valves, including dimensional sketches of all terminals. Section 1 covers flexible shafting for use where there are a number of bends, and includes valve couplings, remote-operating terminals, and handwheels; Section 2 covers standard rigid reach-rod controls; Section 3 covers gear boxes, including a 90-deg unit and 300-deg swivel geared joint that operates in any angle from 0 to 300 deg. Bulletin 618, 20 pages. Stow Mfg. Co., 443 State St, Binghamton, N. Y.

Circle 630 on Page 19

Electronic Connectors

Covers an expanded line of precision, microminiature, electronic connectors, designated Series MM-22. They are available in 14 sizes with 5 to 104 contacts. Complete description, illustrations, electrical and mechanical specifications, outline drawings, and ordering information are included. Form MM-861, 6 pages. Electronic Sales Div., DeJur-Amsco Corp., 4501 Northern Blvd., Long Island City 1, N. Y.

Circle 631 on Page 19

Pumping Units

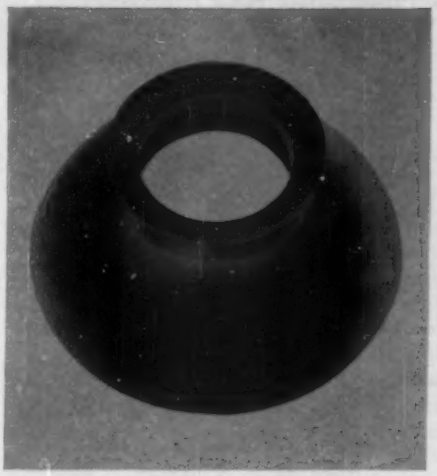
Engineering data are arranged for selection of centrifugal, axial, or mixed-flow pumps best suited to individual and specific applications. Includes parts listings and prices, along with reference section carrying data relating to pumps, hydraulic design, and general tables and charts frequently required in the application of moving liquids. "Pic-A-Pump" Catalog, 1008 pages. Write on company letterhead to Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.

Electronic Parts, Products

New in the 1962 catalog is a 13-page semiconductors directory which presents transistors, diodes, and other semiconductors in numerical order with quantity price breakdowns. Includes detailed listings of industrial electronic products, ready-made electronic instruments, and customer-assembled Knight-Kit equipment. Other features include high-fidelity equipment, tape recorders and accessories, selection of stereophonic records and tape recordings, and technical book section. 592 pages. Write on company letterhead to Allied Electronics Corp., 100 N. Western Ave., Chicago 80, Ill.

ElastaCAST®

SOLVES CRITICAL MATERIAL SELECTION PROBLEMS



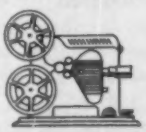
Automotive Ball Joint Seal. *"30,000 miles without ball joint lubrication" resulted from Ford Motor Company's use of oil-resistant ElastaCAST for ball joint seals in its 1961 Fords, Mercurys and Lincoln-Continentals. This application takes advantage of ElastaCAST's abrasion resistance, tear strength, excellent weathering properties and low permanent set.*

If you are planning a product that requires a material with unusual properties, take a look at ElastaCAST. Let us work closely with you, particularly in your early design work; experience has shown us that definite savings in design, production and the finished part generally result.

ElastaCAST is a new liquid polyurethane elastomer possessing an unusual range of mechanical and physical properties — such as outstanding abrasion, tear and ozone resistance, oil and gas resistance and high load-bearing. Here's a whole new sales advantage made possible through our rubber and plastics technology. Call us about your tough or unusual applications.

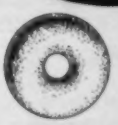
ACUSHNET PROCESS COMPANY
760 Belleville Avenue, New Bedford, Mass.

Acushnet

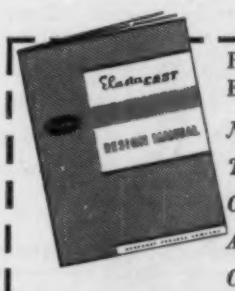


Light Drive Rolls *of ElastaCAST assure longer life... higher drive friction.*

Shoe Toplifts *of ElastaCAST outwear nylon, rubber or leather . . . take impact bearing loads up to 7,000 psi.*



Textile equipment bearings *of ElastaCAST outlast metal as well as conventional rubbers and plastics.*



Please send my copy of your new 16-page ElastaCAST Design Manual.

*Name*_____

*Title*_____

*Company*_____

*Address*_____

*City*_____ *Zone*_____ *State*_____

Circle 316 on Page 19

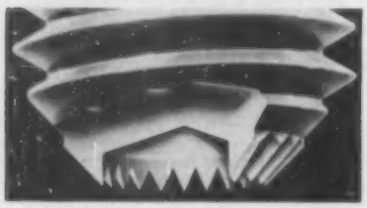
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Counterbore Set Screw

has extremely acute angle at point of entry

New set screw incorporates a counterbore knurled cup point with an extremely acute angle at the point of entry. It permits easy, deep penetration and greater knurl contact. Result is a positive locking action and excellent vibrational holding power at the recommended seating torque. Designated Unbrako High Torque, screw also has a smoothly radiused thread root which



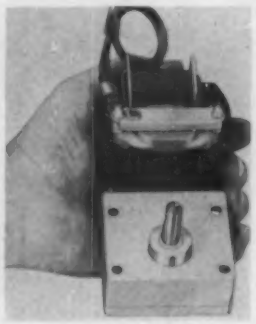
distributes stresses to permit high tightening torques, and adds metal to the area between the root of the thread and the Unbrako socket. Screw is available in sizes No. 4 through 1 in. **Standard Pressed Steel Co.**, Jenkintown, Pa.

Circle 632 on Page 19

Gear Motor

develops up to 30 lb-in. torque

No. WF fractional-horsepower gear motor has a flat configuration so that it will fit into minimum space. It develops up to 30 lb-in. torque for continuous duty and has a higher rating for certain limited-duty applications. It is powered by a two-pole, shaded-pole, unidirectional induction motor. Unit measures 2 21/32 x 2 11/32 x 4 15/16 in., operates on 115 v, single-phase, 60-cycle. It is available with brake, fan, special leads, thermal protector, shaft modifications, various lubrication provisions, and any one of three different motors. Although designed for horizontal mounting with the motor above the shaft, it can be mounted in any position. **Merkle-Korff Gear Co.**, 213 N. Morgan St., Chicago 7, Ill.



Circle 633 on Page 19

Flow Regulators

permit flow selection from 0.3 to 1.5 gpm

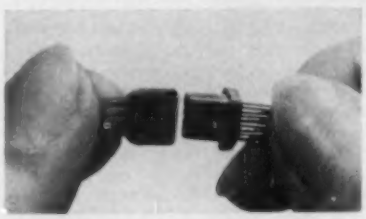
Externally adjustable, restrictor-type flow regulator has a linear reference scale permanently stamped on the stationary sleeve for adjusting valve flow. Valve is designed for 10 to 100-psi hydraulic circuits requiring constant, accurate regulation of low flow rates. It permits precise flow selection from 0.3 to 1.5 gpm. Adjusting screw requires 20 turns to go from minimum to maximum setting, allowing fine adjustment of flow. The accuracy of the regulated flow is then held within ±2 per cent of the flow setting, regardless of variations in system pressure. Constructed of stainless steel and anodized aluminum, flow regulator can be used in any low-flow circuit handling fluids compatible with these materials. Operating temperatures range from −65 to +275 F with no change in valve performance. **Fluid Regulators Corp.**, 313 Gillette St., Painesville, Ohio.

Circle 634 on Page 19

Microminiature Plugs

have contact center spacing of 0.05 in.

Micro-D plugs are light in weight, and are shock and vibration resistant. Contact center spacing of 0.05 permits a density of up to 420 contacts per sq in. Units meet or exceed requirements of MIL-C-8384B. Panel, surface-board, edge-board, or component-board modules are available. Units are currently available



with 9, 15, or 37 contacts. **Cannon Electric Co.**, 3208 Humboldt St., Los Angeles 31, Calif.

Circle 635 on Page 19

Miniature Slip Clutches

provide constant torque transmission

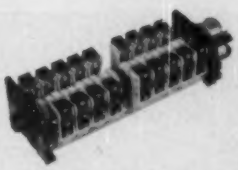
Adjustable miniature slip clutches have application as overload couplings or where a constant-torque drive is required. Locking-type set screw adjusts torque transmission through a range of 0 to 4 lb-in.

Find the time control you need here

...or write for Cramer Catalog GB-910

STOP CLOCKS

Type 691: Time totalizer to measure and indicate elapsed time intervals. All-electric start, stop, reset permits local or remote control. Ranges 60 seconds or 60 minutes in 1/100ths, or 60 minutes in seconds. Accuracy within .01 second.



CYCLE TIMERS

Type 540: Multiple-program cycling timer synchronizes up to 20 independent load circuits. Time ranges from 1 sec. to 11 days. Cams field adjustable by user to factory standards. Versatile unit changes program sequence and timing with approx. ½ of 1% full cycle accuracy.

INTERVAL TIMERS

Type 241: Featuring pushbutton start, progress and setting pointers, and repeatability within ¼ of 1% of full scale. Manually set, unit resets automatically at end of timed interval, opening load circuit. Ranges from 6 seconds to 24 hours.

CYCLING TIMER

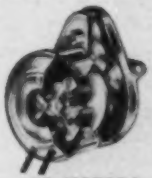
Type 553: Miniature hermetically sealed timer with 1 to 5 load switches, actuated by motor driven cams. Time ranges from 5 secs. to 30 hours. Meets relevant tests MIL-E-5272B. Weighs 7 oz. max. including 60-cycle or 400-cycle motor. Accuracy is .5% full cycle time.

SYNCHRONOUS MOTORS

Type 117: Compact, high performance Cramer permanent-magnet synchronous timing motor. Available in speeds from 60 RPM to ½ RPD, motor starts and stops instantly, is permanently lubricated and operates only at truly synchronous speeds.

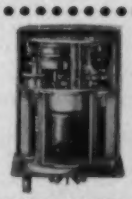
TIMERS TO "MIL" SPECS

Type 620: Miniature elapsed time indicator for 115 volt, 60 or 400 cycle operation. Meets relevant tests of MIL-M-7793B and MIL-E-5272B, dimensional requirements of MS-28053 and NEMA. Registration 9,999.99 hours, weight 4 oz., hermetically sealed.



DC MOTORS

Type 800: For any specified voltage from 3 to 30 volts DC. Geared speeds 2 RPD to 900 RPM, output 30 in. oz. at 1 RPM. Speeds 960 to 3000 RPM without gear train. Current drain as low as 30 ma. One of many industrial and military DC motors.



TIME DELAY RELAY

Type 430: Hermetically sealed to meet relevant tests MIL-E-5272 and MIL-STD-202. Provides fixed time delay from 1 sec. to 30 min. between closing of control circuit and subsequent closing or opening of 1 to 5 load circuits. Constant speed 25, 50, 60 and 400 cycle AC or DC motors.

TIME DELAY RELAYS

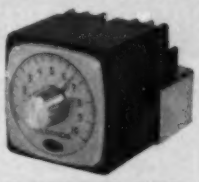
Type 412: Provides adjustable time delay between operation of control circuit and subsequent closing or opening of load circuit. Setting pointer and independent progress pointer, 300° scale. Repeat accuracy ¼ of 1%. Ranges 6 seconds to 24 hours.

PERCENTAGE TIMERS

Type 610: Adjustable automatic timer to control percentage of time an electrical circuit is closed or open out of a definite time cycle. Excellent to control operating time of oil burners, furnaces, etc. Approved by U.L. for industrial control applications.

RUNNING TIME METERS

Type 633: Reliable means of recording elapsed time to industrial accuracies. For 115 or 220v, 60, 50, or 25 cps; also 115v 400 cps, and specified DC from 6 to 32v. Ranges 9,999.9 seconds to 99,999 hours. With or without reset, round dials, or hermetically sealed.



ELECTRONIC TIMER

Type 940: Fully transistorized, compact, high load capacity. No re-cycling effect. Controls 0.02-second interval with repeat accuracy of ±0.01 second. Plug-in load relay replaceable in field. Available as interval timer, time delay relay, or pulse generating timer.

There are many other timing devices — literally hundreds of them — engineered by Cramer for exacting industrial and military applications. Accurate, dependable performance of all Cramer products is assured by sound basic design, careful assembly and 100% inspection. Here, at Cramer, you're most apt to find the answer to your timing problems.

Cramer Division • Centerbrook, Connecticut

GIANNINI CONTROLS CORPORATION

LEARN MORE about these and other Cramer products. Write for free bulletins on the types that interest you or catalog GB-910, or describe your timing problem and let us help you solve it.

Circle 317 on Page 19

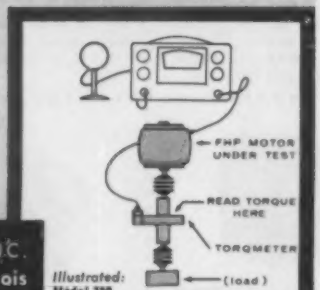
SENSITIVITY UNEQUALED

with FHP TORQMETERS

For ACCURATELY MEASURING Rotating and Static TORQUES of FHP motors, gear-train efficiencies, ball bearings, servos, synchros, potentiometers, hair springs, and many other applications and devices.

We invite your inquiry for complete information and prices . . . or, send your specifications and application needs.

Illustrated:
Model 783 OZ-TORQMETER
measures from .05 to 80 oz. — inch
Also available:
Model 782 GRAM-TORQMETER
measures from .25 gm-cm to 100 gm-cm
Model 784 POUND-TORQMETER
measures up to 200 lb. — inch
Model 781 GRAM-TORQMETER
measures from .05 gm-cm to 5 gm-cm



Illustrated:
Model 790
TACHLITE (STROBE-TACHOMETER)
Self-synchronizing, no drift.

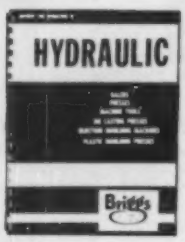
POWER INSTRUMENTS, INC.
7352 North Lawndale Ave. • Skokie, Illinois

NOTE: A few choice territories available for experienced representation.

Circle 318 on Page 19

BRIGGS OFFERS YOU, FREE, A 12 PAGE MANUAL ON HYDRAULIC FLUID CIRCUITS AND HYDRAULIC OIL FILTRATION

HERE is a big 8½" x 11", file size, 12 page, fully illustrated booklet. It's brimful of technical data and drawings that every designer and operating engineer will want to read or keep for ready reference. Write for your copy. No obligation.



Briggs

HYDRAULIC
OIL FILTERS

FILTER/SEPARATORS
AIR AND GAS LINE FILTERS
REPLACEMENT FILTER CARTRIDGES

THE BRIGGS FILTRATION CO., DEPT. 398 WASHINGTON 16, D. C.

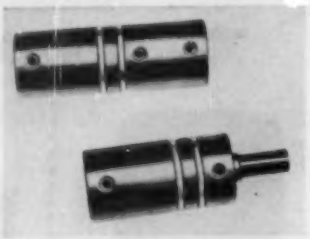
YES AT NO COST OR OBLIGATION, SEND ME THE ABOVE HYDRAULIC MANUAL

NAME .....

COMPANY .....

ADDRESS .....

Circle 319 on Page 19



Clutch parts are oil-impregnated sintered alloy and require no lubrication. Model K is designed to couple two shafts; Model M is supplied with a ¼-in. bore on one end and ¼-in. shaft on the other. **Precision Specialties Inc.**, Pitman, N. J.

Circle 636 on Page 19

Chemical-Resistant Paint

resists acetic, hydrochloric, and dilute sulfuric acids

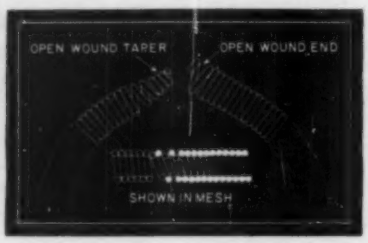
Chem-Rem chemical-resistant paint can coat many surfaces previously regarded as unpaintable. In addition to acid resistance, it resists bleaching solutions, dilute caustic soda, ammonia, and other alkalies. Elastic surface is impervious to moisture and is unaffected by oil, gasoline, or temperature fluctuations. Paint is available in nine standard colors. Applied by brush, spray, or dip, it dries to the touch in 3 hr and sets in 24 hr. **Speco Inc.**, 7308 Associate Ave., Cleveland 9, Ohio.

Circle 637 on Page 19

Garter Springs

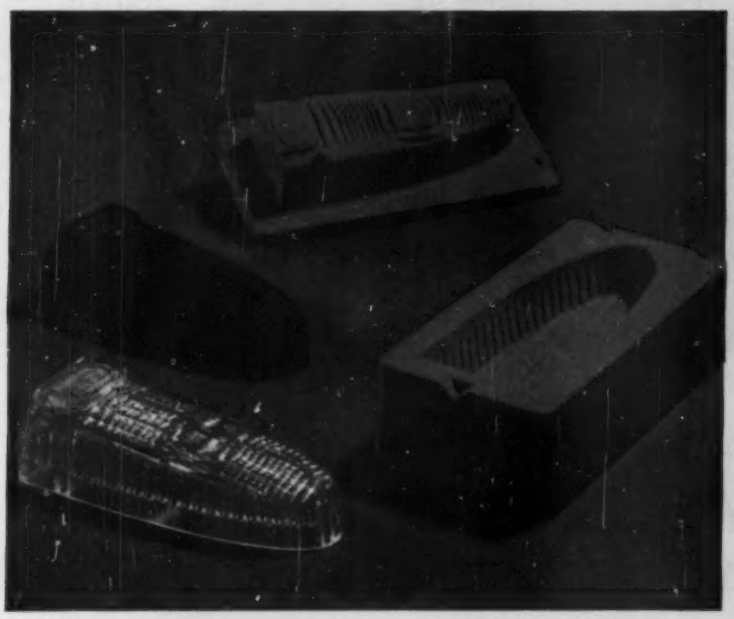
have positive end connection

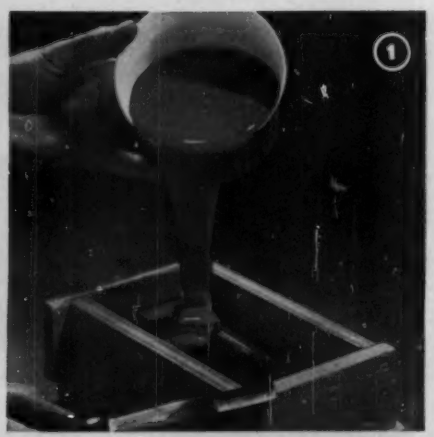
Available in a wide range of commercial sizes in compression and extension types, new garter springs can be used in high load and severe service applications. Springs incorporate a positive end connection designated Interlock, which provides smooth continuity of OD across the



SILICONE NEWS from Dow Corning

Prototypes unlimited





Pour yourself a Silastic RTV mold and...start casting!

By using the "original" for a model, you can quickly pour simple cavity or split molds and in a few hours be casting exact duplicates! It's that easy when the mold-making material is Silastic® RTV.

This fluid silicone rubber sets-up at room temperature in minutes or hours depending on the RTV system you select. It cures without heat to a firm, flexible silicone rubber capable of tolerating casting temperatures of many plastics and molten alloys . . . up to 500 F.

Mold making with Silastic RTV is quick, inexpensive and practical — whether you want one duplicate or dozens. What's more, RTV molds produce dimensionally accurate parts having finest hairline detail.

Here are the simple steps followed in producing this taillight lens —

(1) After mixing with catalyst, Silastic RTV is poured into the form, over the original pattern to produce one half of the mold. Because Silastic RTV releases readily from most materials, no parting agent is necessary.

(2) After the RTV cures, the "half-mold" is turned over and alignment notches cut. The RTV surface is coated with release agent and more Silastic RTV poured to form a mating second half of the mold.

(3) After removing the original pattern, clamp the two RTV molds together, drill sprue holes and air vent — and you are ready to cast prototypes that are exact replicas of the original. The photo shows prototype being taken from the mold.

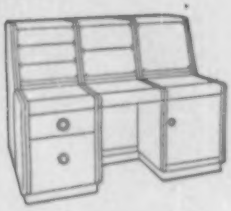
For detailed information on Silastic RTV, write Dept. 6922a, Dow Corning Corporation, Midland, Michigan.

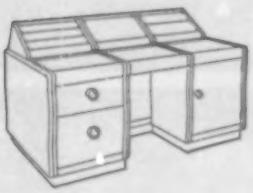
first in silicones

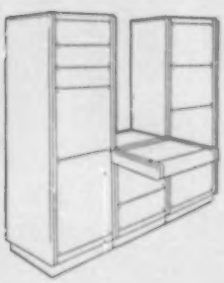
Dow Corning

Circle 320 on Page 19

EMCOR® STANDARD CABINETS







- Cut enclosure design time. Select your packaging needs from a complete line of standard and heavy duty EMCOR Cabinets.
- EMCOR MODULAR ENCLOSURE SYSTEM Cabinetry provides for thousands of control center combinations.
- Choose from hundreds of EMCOR Cabinet widths, depths and heights offering an exclusive combination of engineered features.
- Engineered simplicity of basic frames and components affords quickest and easiest erection of control center assembly.
- EMCOR Cabinetry Engineers backed by the research and development "know-how" of the Roy C. Ingersoll Research Center set the pace for the packaging needs of electronics, instrumentation and electro-mechanical engineers from coast to coast.
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Condensed Version of Catalog 106 Available Upon Request.

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Originators of the Modular Enclosure System

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Division of Borg-Warner Corporation

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joint. Connection remains secure even when excessive stresses cause deformation of the spring. Applications include oil seals, diaphragms, drive belts, brush holders, clutch segments, special fasteners, retainers, expanders, connectors, and O-rings. **Associated Spring Corp.**, Bristol, Conn.

Circle 638 on Page 19

Rotary Bleeder Valve

for pressures to 500 psi

Model GL-5 stainless-steel, rotary-type bleeder valve for use in all hydraulic and pneumatic systems is a semiautomatic unit. Standard model is designed for operating pressures to 5000 psi, temperature range of −65 to +275 F, and hydraulic MIL-O-5606, water, fuel, air, and

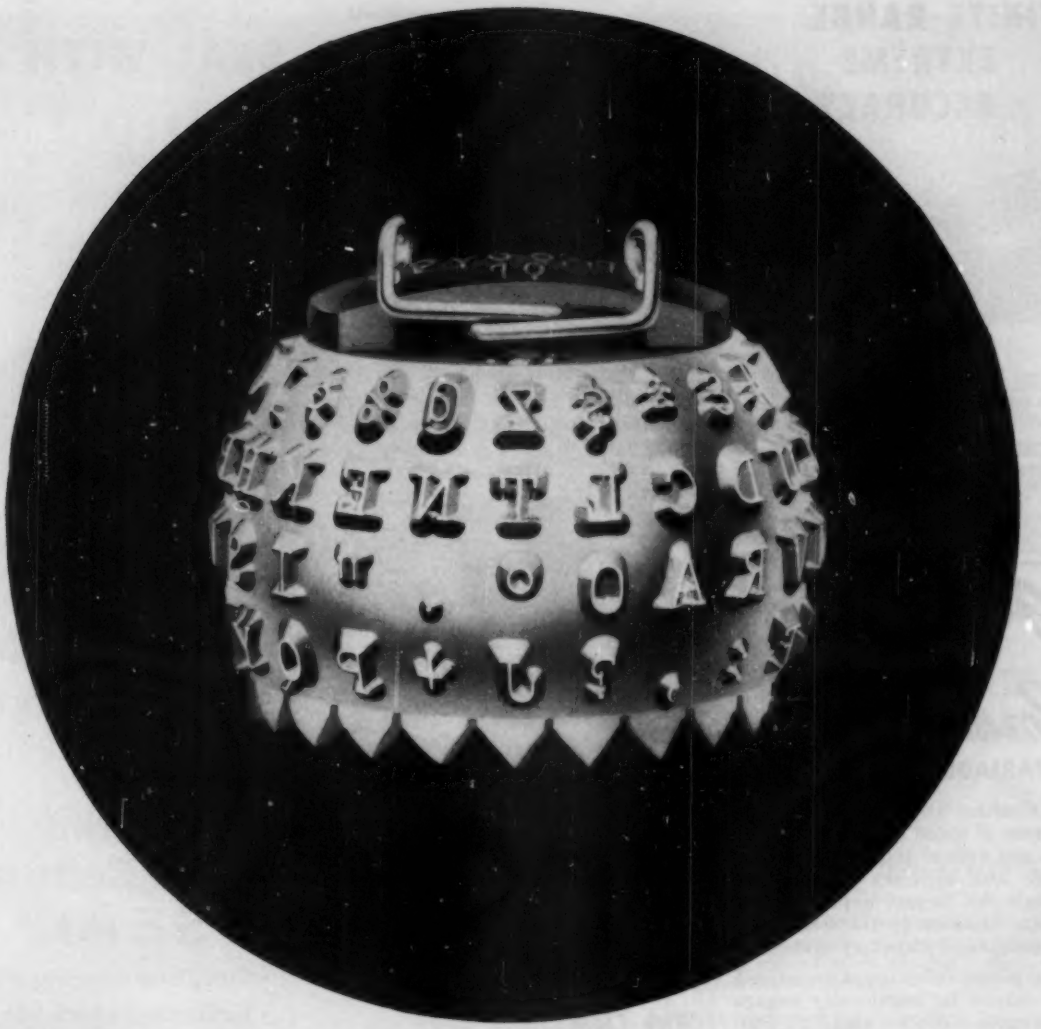
all other normal industrial or aircraft oils. It weighs 1.8 oz. Maximum clockwise torque of 5 lb-in. on the knob, at 5000 psi, is required to open the valve fully. **Greer Hydraulics Inc.**, 5930 W. Jefferson Blvd., Los Angeles 16, Calif.

Circle 639 on Page 19

Epoxy Paper-Base Laminates

for printed circuitry and terminal board uses

Grades EP-800 and EP-800-T are a flame-retardant unclad and a copper-clad epoxy paper-base laminate, respectively. They provide reliability, copper - to - laminate bond strength, insulation resistance, and flame retardance where glass-base laminates are not required. Grades are designed specifically for printed circuitry and terminal-board applications and are named Micaply. Initial bond strengths have an average minimum of 14 lb per in. for 2-oz copper cladding and 11 lb per in. for 1-oz cladding. Laminates



PLASKON UREA...ENABLES IBM TO MOLD A NEW WAY TO WRITE

The precision engineered typing element of IBM's new Selectric® carriageless typewriter is molded of PLASKON® UREA.

No bigger than a golf ball, this nickel-plated urea sphere does the work of a basketful of type bars—tilting and rotating at high speed as it selects and types the desired character or symbol.

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Circle 322 on Page 19

INFINITE RANGE
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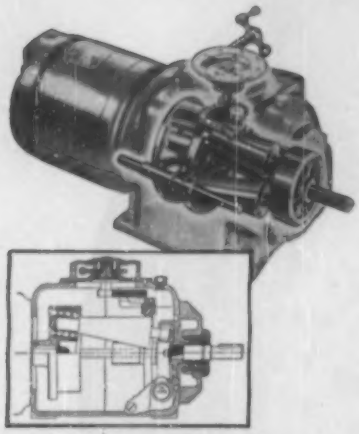

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Graham
VARIABLE SPEED DRIVES

The Graham Drive gives extreme accuracy of speed holding and reset from any desired top speed to zero. Range and accuracy are assured through the correct application of metallic traction in the first stage of a compound planetary system.

Three planet roller cones are canted in a carrier to tractionally engage an encircling control ring . . . Pinions on the large ends of the rollers mesh with a ring gear joined to the output shaft . . . Speed is changeable running or stationary . . . Planetary action provides overload protection. The dial permits settings to one part in 4000.

A wide choice of built-in motors, reducers and controls is available in sizes-fractional to 3 HP. Write for full performance data.

GRAHAM EXTRA FEATURES

- Any desired maximum speed to zero, including reverse.
- Straight line extension of a standard motor for true compactness.
- Controls tension, proportion, synchronization, etc., from any type of control signal.

Ask for Graham Catalog 550.

GRAHAM TRANSMISSIONS, INC.
Menomonee Falls, Wisconsin

Circle 323 on Page 19

are available in popular thicknesses in sheet sizes 18 x 36, 20 x 36, and 21 x 36 in. **Mica Corp.**, 4031 Elenda St., Culver City, Calif.

Circle 640 on Page 19

Variable-Speed Pulleys

have infinite speed range of 6:1

Small, lightweight, combination metal and reinforced-nylon pulleys are available in three sizes for fractional-horsepower applications using ¼, ⅜, and ½-in. V-belts up to ½

hp. Pulleys have infinite speed range to 6:1, with hand-knob adjustment, and are made for ¼, 5/16, ⅜, ½, and ⅝-in. shaft diam. Pitch-adjusting knob can be locked in position. **Rampe Mfg. Co.**, 14915 Woodworth Ave., Cleveland 10, Ohio.

Circle 641 on Page 19

Wire Cloth

of high-temperature, stainless-steel alloy

Wire cloth woven of a high-temperature, stainless-steel alloy, NS-A286, can be used in jet-engine, gas-turbine, and other applications at temperatures to 1000 F. Parts made of the wire cloth can be hardened after forming or fabricating. Cloth can be made in various meshes, wire sizes, and weaves. Principal elements of the alloy are 15.00 Cr, 25.25 Ni, 2.10 Ti, and 1.60 Mg. **Dept. RDT, National-Standard Co.**, Niles, Mich.

Circle 642 on Page 19

Battery Holders

accommodate popular zinc, mercury, or alkaline sizes

Battery holders for use in portable equipment are beryllium copper or

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Try one and see for yourself. Sizes from .875" to 2.500" shaft diameter are available for immediate delivery. Send today for catalog and price information. No obligation, of course.

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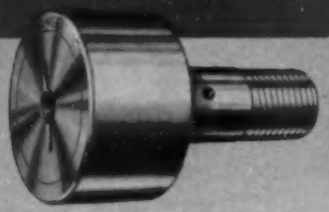
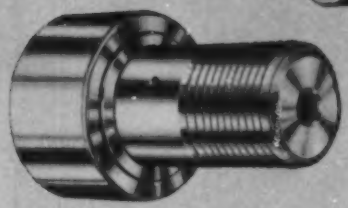
Circle 324 on Page 19

Give your Cam-Activated, Guide and Track Applications the ultimate in smooth, rugged, shockproof operation!

ORANGE CAM FOLLOWERS

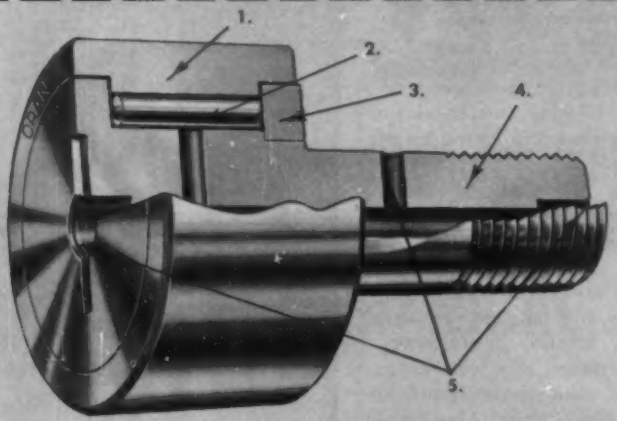


TYPE S
Standard Stud



TYPE H Heavy Duty Stud
Provides an average of 20% greater beam strength of the stem where severe operating conditions exist.

Orange Cam Followers are engineered and constructed to provide the maximum in precision, friction-free, durable service for follower roller mechanisms. Available in 22 standard sizes from 1/2" to 4" O. D., with either standard or heavy duty studs. Chrome, Cadmium or Black Oxide finishes can be supplied; also seals where conditions require. Check these features!



1. Centerless ground, heavy-sectioned outer race is made of thru-hardened, high quality bearing steel. Precise concentricity provides true radial running, prevents vibration to protect delicate mechanisms.

2. Small diameter rolls are made of high grade bearing steel, electronically gauged for uniformity of size.

3. Case-hardened end plate permits the use of effective press fit for retention.

4. Induction-hardened stud assures maximum hardness of the roller surface, with core toughness to withstand high shock loads. Slotted ends for convenient screw driver mounting.

5. Selective lubrication for design flexibility. Drilled for drive type fitting. Closing plugs also furnished.

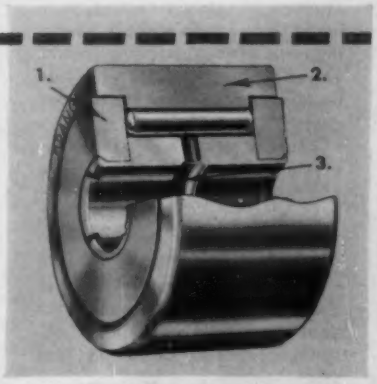
ORANGE CAM YOKE ROLLERS

Simplified, rugged construction is ideal for yoke mounting in machinery involving cam action or control of machine elements requiring guide or support rollers. 18 sizes from 3/4" to 4" O. D. Can be furnished with Chrome, Cadmium or Black Oxide finishes. Supplied with seals where required.

1. Staked end plate. The inner race is zone-hardened on the roller path for wear-resistance, while the ends remain more ductile to permit substantial staking for self-retention.

2. Heavy outer race centerless ground to precise concentricity and thru-hardened to carry heavy loads.

3. Lubrication passage provided from center channel.



WRITE FOR 44-PAGE REFERENCE MANUAL giving full specifications on Orange Cam Followers and Yoke Rollers, plus complete line of Orange Roller Bearings.

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556 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
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. . . means alloy flexibility

Through investment casting, your metal parts can be made in a wide range of ferrous, nonferrous and super alloys. Results — better performance...longer life...lower costs!

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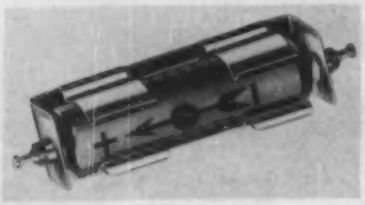
Better alloys often cost no more than the "inexpensive" ones when your part is an investment casting. What counts is *castability*, not machinability.

Write for complete technical and facilities information.

HITCHINER
Milford 2, New Hampshire

Circle 326 on Page 19



steel, and withstand severe operating conditions. Contacts are silver plated, nylon insulated, and color coded to denote battery polarity. Holders accommodate all popular sizes of zinc, mercury, or alkaline batteries. **Augat Inc.**, 33 Perry Ave., Attleboro, Mass.

Circle 643 on Page 19

Adhesive-Backed Nameplates

have abrasion and corrosion-resistant surface

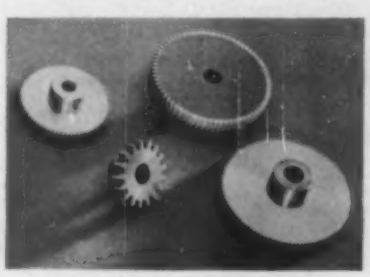
Super/Cal adhesive-backed nameplates are available with quick-release paper backing, water-release liner, and solvent and heat-activated adhesives. Special-purpose adhesives are furnished to order. Plates have corrosion and abrasion-resistant suface, good color fastness, and good dielectric properties. Nameplates are permanently self-bonding to any surface without pins, rivets, staples, or fasteners. They are furnished in a wide range of colors and color combinations, in dull or shiny finish. **Aluminum Nameplate Corp.**, 32-01 57th St., Woodside, L. I., N. Y.

Circle 644 on Page 19

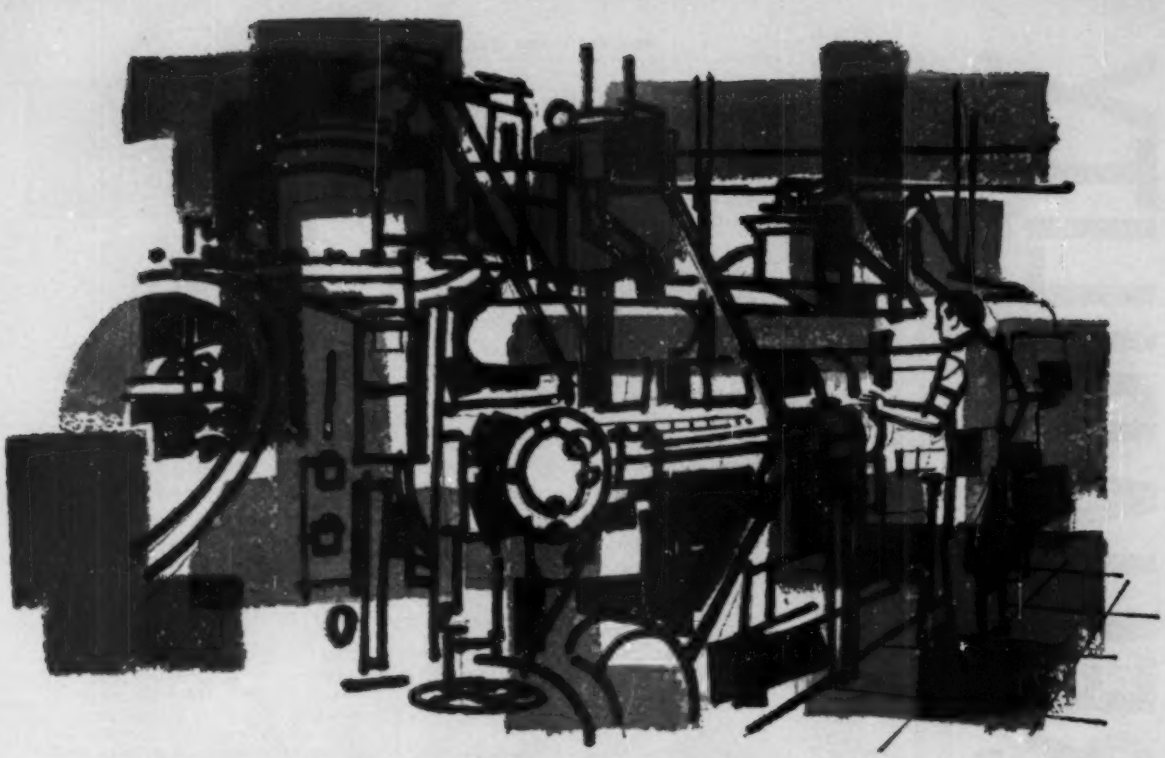
Precision Gears

in 24 to 200 diametral pitch

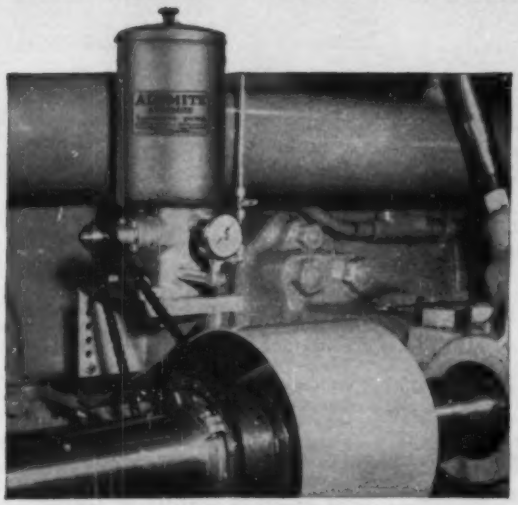
Stock precision gears, manufactured to military requirements, cover diametral pitch ranges from 24 to 200. They are available in stainless steel, aluminum, nylon, and linen phe-



Circle 327 on Page 19



No other centralized lubrication system can offer the advantages of Accumite with the ALEMITE MECHANICAL PUMP AND TIMER!



Close-up of the Alemite Mechanical Pump and Timer driven by timing shaft by means of a chain and sprocket.

By utilizing a chain and sprocket to transfer rotary motion to an Alemite Mechanical Pump and Timer you can supply efficient, automatic Accumite Centralized Lubrication to as many as 400 points or bearings. That's over 30 times the capacity of other pumps! The Alemite Pump eliminates the "rat's nest" of lines other systems require—serves all bearings with a single line. Shots are measured at the bearing, *not at the pump*. Line length is no factor and any size shot from .00055 oz. to .012 oz. or more can be delivered to any point. Two more Alemite advantages are the big capacity 5-pint reservoir and an alarm system assuring accurate, positive lubrication.

The Alemite Pump and Timer is completely mechanical, uses no air or electricity. Cam operated valve closes at intervals determined by the pump input shaft speed to deliver positive, measured amounts of lubricant to each point in the system. Measurement is by piston stroke, wear not a factor, pressures remain constant and can be read on any type gauge.

Contact your local Alemite distributor or write for free illustrated literature on the Alemite Mechanical Pump and Timer and the Accumite Centralized Lubrication System.

Symbol of SW Excellence

ALEMITE DIVISION
STEWART-WARNER CORPORATION

Dept. BB-101, 1850 Diversey Parkway, Chicago 14, Illinois

In Canada: Stewart-Warner Corporation of Canada, Ltd., Belleville, Ontario

Circle 328 on Page 19

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IN MECHANICAL SEALING
MEANS
DURA SEAL
The PERFECT SEAL
ROTATES WITH THE SHAFT
"THE ENGINEERED MECHANICAL SEAL"
because Dura Seal is backed by 25 years of experience — because Dura Seal is supported by continuous research for meeting modern processing demands — because Dura Seal is engineered to meet your specific operating conditions — because Dura Seal is nationally sold and serviced.
For Free Engineering Counsel on Your Sealing Problems, write DURAMETALLIC CORP., Kalamazoo, Michigan
Circle 329 on Page 19

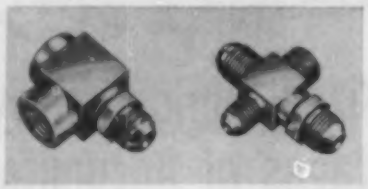
nolic, in either split or clamp-type hubs. Gears meet AGMA Precision 1, 2, and 3 standards. Special gears are also made to NASA standards. **Tech-Ohm Electronics Inc.**, 36-11 33rd St., Long Island City 6, N. Y.

Circle 645 on Page 19

Hydraulic Fittings

in cross, tee, and elbow shapes

Maniport MK hydraulic fittings permit custom assembly of hydraulic manifolds from standard components. They are available in cross, tee, and elbow shapes in eleven sizes from ⅛ to 2 in. Each fitting is equipped with a standard female port on one end and a male swivel-head fitting opposite, making it possible to screw a series of fittings together to form a manifold. Fittings are also equipped with a variety of tube and hose-outlet fittings to permit piping into and out of the manifold. Ten combinations of male and female pipe, flare, and self-flare outlet connections are available. Fittings coin their own metal-to-metal seat, providing zero leakage under pressures to 20,000 psi, and they are reusable without leakage. **Flodar Corp.**, 16911 St. Clair Ave., Cleveland 10, Ohio.



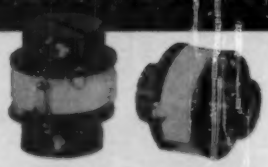
Circle 646 on Page 19

Flexible Connector

conveys gas and fluids under temperatures to 750 F

All-metal bronze and carbon-steel flexible connector, designated UC3, conveys gases and fluids under temperatures to 750 F. Stainless-steel versions are suitable for temperatures

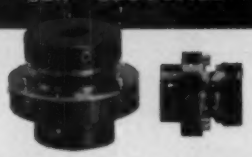
TIC OF ACTON
MINIATURE FLEXIBLE COUPLINGS



FEATURE • No Backlash • Compactness and Lightweight • Accommodate both lateral and angular misalignment • Choice of types offer clamping or set-screw hubs

Type MPC-1 consists of two flanged aluminum hubs and nylon or Delrin discs with V-grooves that are displaced 90° with each other. Discs are fastened with stainless steel springs loading ball pivots against V-grooves. Dimensions ⅞ x ⅞ in.
Type MPC-2 has two cylindrical aluminum hubs, each with two ball pivots attached. Hubs are attached to a pair of flexible phosphor bronze discs which hold and load the ball pivots. Dimensions ¾ x ½ in. Both types have range of bores to accept shafts from .120" to .250" and meet MIL-E-4970 and withstand −80° to 200°F and shock to 100 G.

TIC OF ACTON
ADJUSTABLE SLIP CLUTCHES

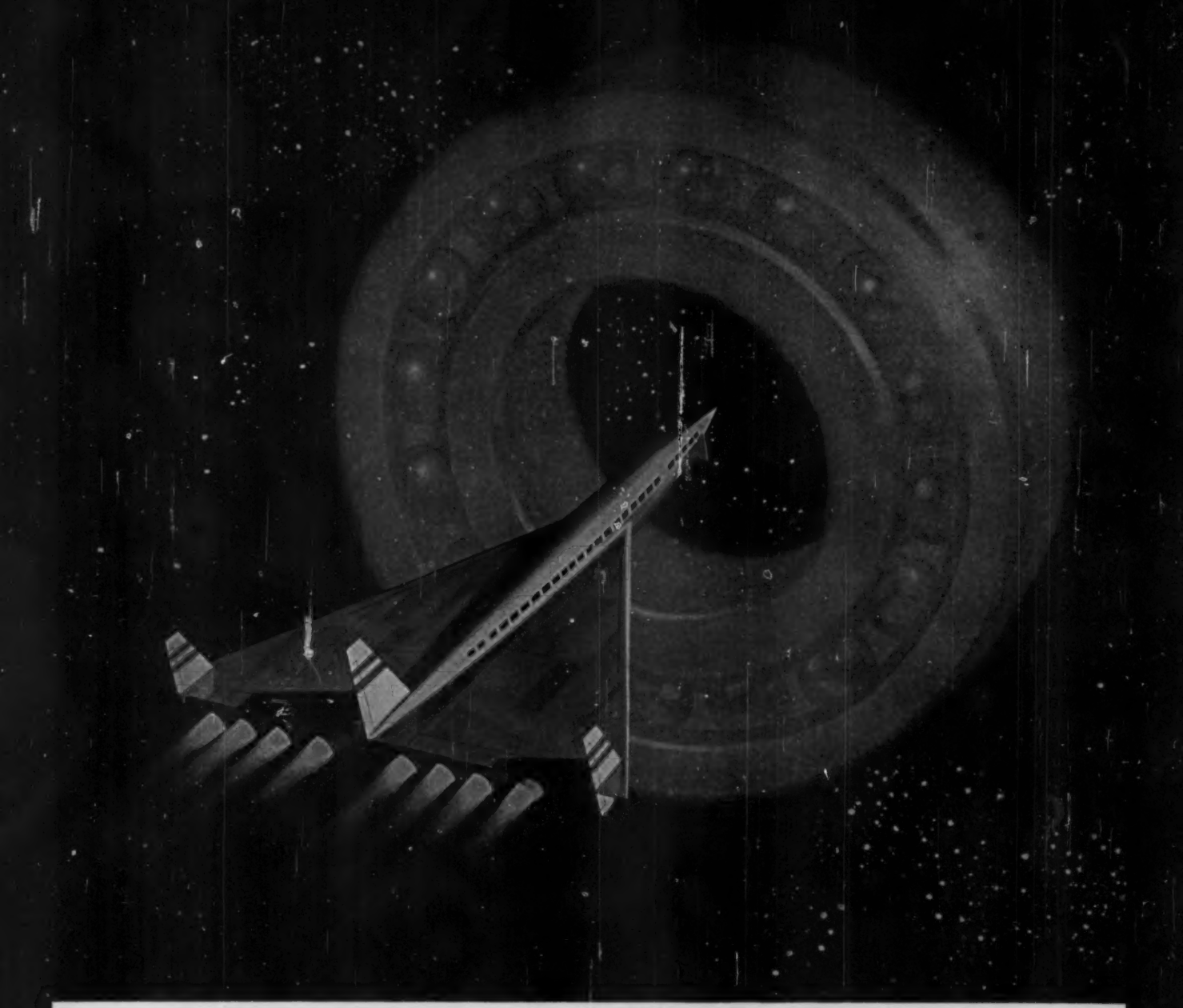


FEATURE • Adjustment over a wide torque range • Compactness and lightweight

Type ASC-1 is ⅜ x 1"
Type ASC-2 Miniature is ⅝" x ⅝"
Both are constructed of aluminum hubs, Delrin on stainless steel clutch plates and stainless steel hardware. These rugged, high performance clutches are friction units to protect components against excessive or inertia shock loads. Range of bores to accept shafts from .120" to .250". These clutches meet MIL-E-4970 specs.

For details on couplings or clutches write

TIC
For further information write
TECHNOLOGY INSTRUMENT CORP.
533 MAIN STREET, ACTON, MASS.
8530 WILSHIRE BLVD.
BEVERLY HILLS, CALIF.
Circle 330 on Page 19



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SKF MOTION ENGINEERING

Advanced ball and roller bearing technology

On special test equipment in SKF's research laboratory, experimental ball and roller bearings are run at temperatures up to 1000° F and above—conditions under which steel becomes red hot and loses its strength, while conventional lubricants burn or boil away. To meet these problems, bearings made of special heat-resisting alloys and exotic new materials are tested and evaluated. New ideas in design and new approaches to lubrication are constantly being investigated.

Bearings to resist extremely high temperatures are needed for improved, high performance jet engines, gas turbines and other equipment. Special SKF bearings have been tested successfully in environments at about 1000° F. Under certain conditions of operation, much higher temperatures are practical.

Research like this is your assurance that SKF will always keep pace with demands for the highest possible performance in all major types of rolling contact bearings —ball, cylindrical roller, spherical roller, tapered roller and precision miniature. SKF Industries Inc., Philadelphia 32, Pa. 6103

Circle 331 on Page 19

Famous PRATT & WHITNEY AIRCRAFT J57 Jet Engine, power plant for Air Force "Snark" guided missile, is geared for both commercial and military performance by *Perkins*. Typical tolerances on *Perkins* gears: .0004 tooth to tooth; .0015 cumulative; .0005 on involute. On spline: .0006 tooth to tooth; .0008 cumulative; .0005 on involute. Most *Perkins* gears are carburized, hardened and ground.

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Rigid PRATT & WHITNEY AIRCRAFT precision requirements spell *performance* . . . top-flight performance. Reason: The future is at stake. And that future can well ride on gear teeth. Since 1940, PRATT & WHITNEY AIRCRAFT gear tolerances have been *Perkins'* standards . . . for commercial gears as well as aircraft. Such precision pays off in longer wear, greater efficiency, lower maintenance cost. That type of precision can pay off for you, too.

This Handy Gear Calculator, easy to use, saves time. *Folder* illustrating Perkins custom precision gears and facilities offers information. Both yours on request.

PERKINS
MACHINE AND GEAR CO.

Dept. 53 West Springfield, Mass.
Telephone: REpublic 7-4751

of 850 and 1400 F. Connector has a braided outer cover and a corrugated inner tube for flexibility and strength. It absorbs expansion movement and dampens vibration. **Universal Metal Hose Co.**, 2133 S. Kedzie Ave., Chicago 23, Ill.

Circle 647 on Page 19

Reduction Gear Boxes

in ¼ through ¾ hp

Single (shown) and double-reduction gear boxes for fractional-horsepower, adjustable-speed drives are available in ¼ through ¾ hp, with

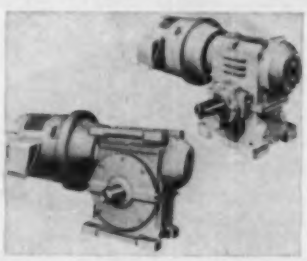
speed variations from 2:1 through 10:1. A ¼-hp drive with 2:1 speed variation gives output speeds from 10 to 4660 rpm. Other sizes and speed variations provide similar output ranges. Lubrication-free pulleys eliminate fret corrosion and pulley wear. **Sterling Electric Motors Inc.**, 5401 Telegraph Rd., Los Angeles 22, Calif.

Circle 648 on Page 19

Right-Angle Gear Motors

in both ac and dc integral types

Type W right-angle gear motors with single-reduction worm gearing are for use with apparatus driven by belts, chains, or spur gearing, as well as through couplings. Available in both ac and dc integral types, units are offered with ac mo-



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Superior offers nuclear-quality heat exchanger and fuel element tubing in a number of stainless steel analyses and Inconel;[1] also in some of the newer materials, including zirconium, Zircaloy 2,[2] Zircaloy 4,[2] columbium and 1% zirconium-columbium alloy. High standards of quality are maintained by such quality-control procedures as Vidigage inspection, air gaging and non-destructive testing.

[1]Reg. TM International Nickel Co. • [2]Reg. TM Westinghouse Electric Corp.

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NORRISTOWN, PA.
West Coast: Pacific Tube Company, Los Angeles, California

tors in NEMA frame sizes 182 (1 hp) to 286U (20 hp) or with dc motors in sizes 187A (1 hp) to 286A (15 hp). **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 30, Pa.

Circle 649 on Page 19

Square Valves

can be mounted in any of four 90-deg positions

New ¼-in. square valves which provide fast actuation have a square body to permit the actuator arm to be mounted in any one of four 90-deg positions. Bases of Tenzaloy are available in bottom and side-mounting styles to hold valve bodies perpendicular or parallel to mounting surfaces. Seven models are offered for either two or three-way operation. Manually operated valves are supplied with vertical-lever, pushbutton, palm-button, or fingertip actuators. Mechanically operated models with cycling speeds to 30,000 per hr are equipped with ball-bearing or roller-arm cam. **Humphrey Products, Div., General Gas Light Co.**, Kalamazoo, Mich.

Circle 650 on Page 19

Explosive Bolt

is fired by 0.6-amp current through protector

The 1-in. dual-cartridge explosive bolt has a demonstrated reliability of 99.982 at a 90 per confidence level. Designed initially for airborne missile applications, it is also for use in ground-support systems, and can be used for underwater applications Over-all length of the bolt is 5 in. with a shank length of 3-5/32 in. having a 1-14 NUF 3A thread. Tensile strength is 35,000 lb. Bolt is fired by application of 0.6-amp current through

MINNESOTA MR RUBBER

FACTS for FILING on

trademark of Minnesota Rubber Company

QUAD·RINGS®

- POSITIVE SEALING UNDER ALL CONDITIONS
- ELIMINATES ALL SPIRAL TWIST FAILURE
- FOUR FLEXIBLE SEALING SURFACES
- LOW FRICTION INSTALLATION
- HIGH DENSITY INJECTION MOLDED
- RUBBER COMPOUNDS TO FIT APPLICATION

POSITIVE SEALING UNDER ALL CONDITIONS—The MR QUAD-RING gives superior sealing in reciprocating, rotary, and static applications at pressures ranging from 0 on up.

ELIMINATES ALL SPIRAL TWIST FAILURE—This costly cause of O-ring failure is eliminated because the relatively square cross-section of the QUAD-RING will not roll.

FOUR FLEXIBLE SEALING SURFACES—give double the sealing effectiveness of the O-ring because of the exclusive seal design. It prevents leakage and requires less squeeze.

LOW FRICTION INSTALLATION—is made possible because of the exclusive quadrilateral design. This permits much higher rotary speeds and gives the seal much longer life.

HIGH DENSITY INJECTION MOLDED—All QUAD-RINGS are molded by MR's exclusive injection molding process to give an exceedingly dense product. There are no voids to cause seal failure.

RUBBER COMPOUNDS TO FIT APPLICATIONS—MR compounds are designed to give the best possible service, using basic polymers such as natural or synthetic rubber, silicone or any other that will perform best under the specific conditions.

QUAD-RINGS are manufactured under U.S. patents RE 24332 and 2,873,132

FOR MORE INFORMATION ON QUAD-RINGS AND A COPY OF THE MINNESOTA RUBBER FACT BOOK . . .

WRITE

NFPA

MINNESOTA MR RUBBER

DEPARTMENT 841 • 3630 WOODDALE AVENUE
MINNEAPOLIS 16, MINNESOTA

VICTOR

TYPE K4

Victoprene on O.D. and outer face; patented lead-into-bore feature. Integrally molded element and case.

TYPE K6

Steel O.D.—Victoprene gasket on inside face. Primary lip retains lubricant; secondary lip excludes dirt, foreign matter.

PROVEN DESIGN

compact, dual-lip oil seals as narrow as ¼-inch

Victor Victoprene oil seals in two types to accommodate varying installation and bore sealing needs, yet provide identical shaft sealing efficiency in even the most limited housing space.

- **DUAL SEALING SURFACES**—Inner lip retains fluid; outer lip excludes foreign matter or confines secondary lubricant.
- **VICTOPRENE ELEMENT**—Developed of improved Buna N synthetic rubber for balanced resistance to lubricants, heat, age deterioration.
- **PERMANENT PRE-LUBRICATION**—Cavity between lips holds lubrication on installation. Reduces frictional drag; extends seal life.
- **NARROW WIDTH**—One-piece integral molded construction for most compact seal housing.
- **POSITIVE SPRING LOCATION**—Molded groove retains spring; uniform pressure on shaft assured. Both types available without spring.
- **POSITIVE BORE SEALING**—Type K4 has bonded-to-case Victoprene on O.D. and outer face; lead-in allows easy installation. K6 has steel O.D. with integral gasket on inside face for bottom of bore seal.

WRITE FOR CATALOG...

Covers above types and all varieties of Victor oil seals; includes service recommendations. Useful to specifiers and buyers. Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill. Canadian plant: St. Thomas, Ontario.

VICTOR

Sealing Products Exclusively

OIL SEALS • GASKETS • PACKINGS

MECHANICAL SEALS

Circle 334 on Page 19

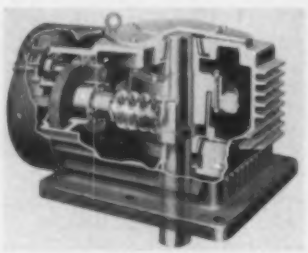
PT06P10 98P connector. **Ordnance Research & Development Co.**, 6856 Tujunga Ave., North Hollywood, Calif.

Circle 651 on Page 19

Speed Reducers

in models with shafts extending up or down

Use of a helical and worm-gear double-reduction combination in HUF and HDF speed reducers provides efficient high-ratio worm-gear reductions. Units are available with output shafts extending either upward (HUF) or downward (HDF). Helical and worm gearing run in a large-capacity, common oil bath for effective cooling and lubrication. HDF units use a dry-well construction to avoid oil leakage. Aluminum or plastic cooling fans are mounted on a high-speed pinion to insure adequate cooling of heavily finned, cast-iron housings. Ratios range from 35:1 to 250:1. Ratings range from fractional to 60 hp; output



torque capacities range to 145,000 lb-in. **Cleveland Worm & Gear Div., Eaton Mfg. Co.**, 3300 E. 80th St., Cleveland 4, Ohio.

Circle 652 on Page 19

Synchronous Motors

for dc stepping duty

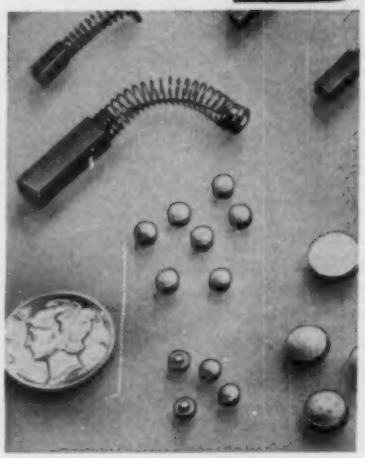
Two Slo-Syn synchronous motor types are available for dc stepping applications. Bifilar types are de-

CONTACTS

Brush Holders

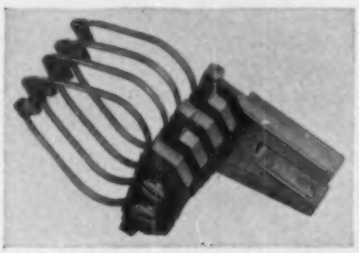
Standard and Special for all makes of slip ring assemblies

...by SCP



Contact grades offered by Superior are most varied and fulfill many combinations of requirements. Superior pioneered in the research, development, and manufacture of silver contact grades, setting standards now universally recognized by industry.

Contacts are ready for attachment to arms or springs. We offer full facilities for attaching contacts to arms or springs and can frequently effect worthwhile savings.



Important to contact and slip ring operation is the brush holder assembly. Together with the selection of proper materials, Superior-assembled contacts and holders provide the vital link in the efficient operation and long life of slip ring assemblies. Superior is thoroughly versed in the requirements of high altitude, noise level, and similar conditions.

Call upon Superior Carbon for assistance with contact problems. You benefit from long experience in this area.

SUPERIOR

SCP

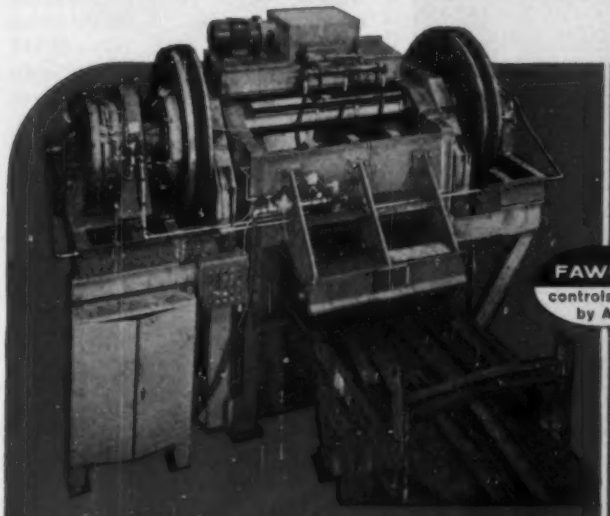
CARBON PRODUCTS, INC.

9115 George Avenue • Cleveland 5, Ohio

Circle 335 on Page 19

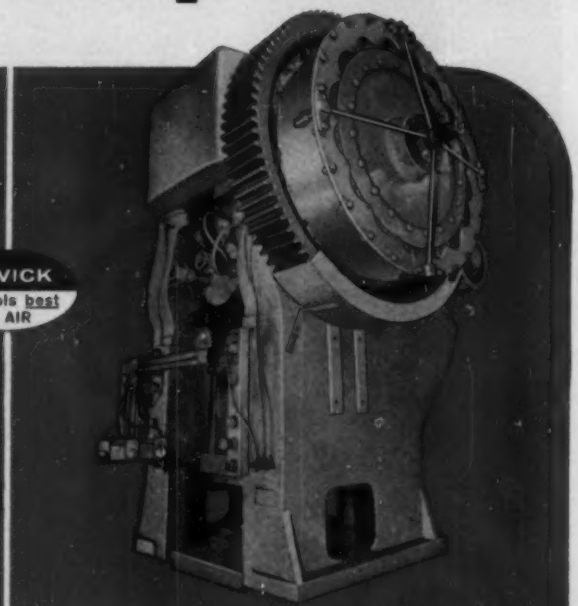
DESIGN or MODERNIZE HEAVY CYCLIC MACHINES

...with Fawick VC Ventorque Clutches



FAWICK controls best by AIR

NEW rotary scrap shear incorporates advanced dual drive system using a Fawick VC Ventorque Clutch in each of two flywheels for synchronized power transmission. Clutches engage opposite ends of main drive shaft instantly, and simultaneously, to avoid shaft twist and provide even knife pressure during operation of the 585-ton-capacity machine. Automatic self-adjustment for wear assures equal torque transmission at opposite ends of shaft, cycle after cycle. Dual element VC Ventorque Brake at shaft end (left) provides braking torque. Shear was designed and built by The Hill Acme Company, Cleveland.



MODERNIZATION of this 600-ton press at major automotive plant has increased production and reduced maintenance downtime. Press Conversion Package includes crankshaft-mounted Ventorque Clutch and spring-applied CS Brake. Since installation three years ago, downtime due to replacement of clutch or brake parts has been completely eliminated.

... for *maximum production under severe conditions*

FAWICK VC Ventorque Clutches and Brakes provide the kind of rugged-duty power transmission that boosts production and precision on even the heaviest machines.

Machine operating speed or efficiency can be increased because Ventorque Clutches respond instantly and accurately. Drum-type air clutch design incorporates ventilated construction for continuous cooling. This keeps torque capacity high and clutch performance at its peak under the toughest operating conditions. Simplified design and cool operation insure long friction life and extremely low clutch maintenance costs.

Ventorques are available in 14 standard sizes with torque capacities from 27,000 to 1,800,000 in.-lbs. at 75 psi. Whether used as original equipment or for modernization, these units are easily installed on all types of heavy cyclic machines.

For complete engineering information and consultation on your application, contact your nearest FAWICK representative or the Home Office.

you can design or modernize these machines with VC Ventorque Clutches:

- power presses
- shears
- draw benches
- cut-off machines
- benders
- rolling mills
- upsetters
- seamers
- crankshaft lathes

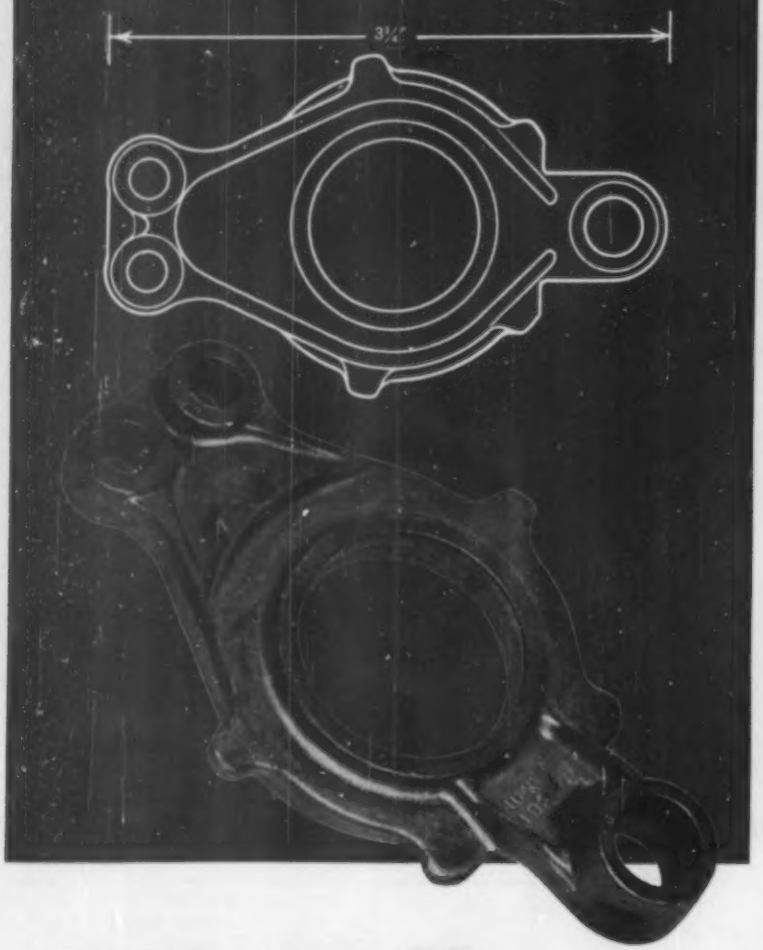
FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
Fawick Canada, Ltd., 60 Front St., West, Toronto, Ont., Canada

FAWICK AIRFLEX

INDUSTRIAL CLUTCHES AND BRAKES

PROBLEM:

High scrap with cast spiders for truck axles



SOLUTION:

Amforge changed the design to accommodate *forging* techniques instead, using lock dies. Some bosses were coined.

There was less scrap. Less machining was required. A lighter, stronger piece resulted—highly important in the weight-conscious trucking industry.

If you happen to have a similar problem part, consult AmForge. Write for our new brochure or the name of your AmForge Sales Engineer.

Remember: *your problems . . . our challenge!*

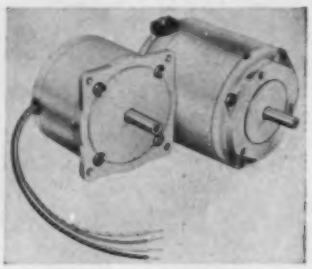
AM FORGE

a division of American Brake Shoe Company, 1220 West 119th Street, Chicago 43, Illinois. Two plants in Chicago, one in Azusa, California.

WHEN IT'S A VITAL PART, DESIGN IT TO BE FORGED

Circle 337 on Page 19

signed for use where push-pull circuitry and a center-tapped power supply is not possible, or where increased torque at high stepping speed is required. A single-ended power source and two SPDT switches are needed. Bifilar units can be stepped by switching from one half of the winding to the other. Four-lead types provide the flexibility needed for use with equipment requiring isolated windings with no common connection. Operation can be either from a single-ended power source with DPDT



switching or from a center-tapped supply with SPDT switching. Both types are available in 50, 100, and 250 oz-in. torque ratings with dc input ratings from 2 to 50 v. **Superior Electric Co.**, Bristol, Conn.

Circle 653 on Page 19

Bearing Bronze

is self-lubricating, high-lead type

Asarcon 230 is a high-lead bronze designed for self-lubricating bushings, bearings, seals, and other applications where strength, resistance to wear and fatigue, and good antifrictional properties are required. Material is available in diameters to 5 in., in standard lengths of 13 in., or cut to specification; in solid or hollow bar, it is furnished in sizes and shapes close to those required for the finished component. **American Smelting & Refining Co.**, 120 Broadway, New York 5, N. Y.

Circle 654 on Page 19

Flange-Type Ball Bearing

for shaft diameters from ½ to 1-7/16 in.

New Life-Lube ball bearing has a flange-type housing with two drilled holes, spaced to allow inter-

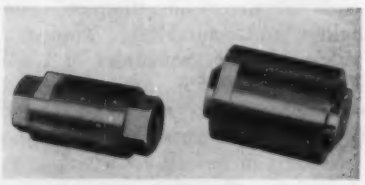
changeability with most other makes of bearing units. Housing has a spherical bore to permit the bearing to self-align. Bearing unit is available for 13 shaft diameters from ½ to 1-7/16 in. Bearing is locked to the shaft by a self-locking eccentric collar which mates with an eccentric cam on the wide inner ring to provide a precision fit on the shaft. No periodic lubrication is required; bearing is sealed for life. **T. B. Wood's Sons Co.**, Chambersburg, Pa.

Circle 655 on Page 19

Ball and Shuttle Valves

for air, water, or oil

Only moving parts in new selector or directional valves are a Hycar ball or stainless-steel shuttle. They shuttle to the left or right, depending on which port is pressurized or has the greatest pressure, and remain until directional flow change is desired. Operating media are air, water, or oil. Units are for ¼-18 and ⅜-18 NPT parts. Two models are for pressures from 30 to 500



and 60 to 1000 psi. **Airmatic Valve Inc.**, 7313 Associate Ave., Cleveland 9, Ohio.

Circle 656 on Page 19

Microminiature Resistors

have range from 25 to 500,000 ohms

New ¼ and ½-w metal film resistors have 0.300 and 0.475-in. body length, respectively, and exhibit performance characteristics comparable

For versatile Moduline® Motocylinders: Westinghouse *relies on* DINGS MAGNETIC DISC BRAKES for fast, frequent stops

The cyclical operation of Moduline® Motocylinders, with as many as 30 thrust and return strokes per minute, demands not only instantaneous braking action but brakes with long, trouble-free service life.

That's why Westinghouse uses Dings Direct-Acting Magnetic Disc Brakes. The Dings Brakes used on Moduline® Motocylinders are estimated to be good for 200,000 to one million stops (depending on application) before adjustment is necessary.

In addition to positive, instantaneous stops and low maintenance requirements, these other Dings Brake advantages will add efficiency to your operations:

- No mechanical linkages to require maintenance. Easily accessible and simple to install—brakes mount on standard NEMA "C" frames. Available for horizontal, vertical or foot mounting. Easily accommodates thru shaft in all standard waterproof and dust-tight enclosures. Wide torque range—1½ to 175 lbs. ft.—easy torque adjustment.
- Fail-safe design in event of power failure. • Standard drip-proof, waterproof or dust-tight enclosures. • Hazardous location brakes UL approved.

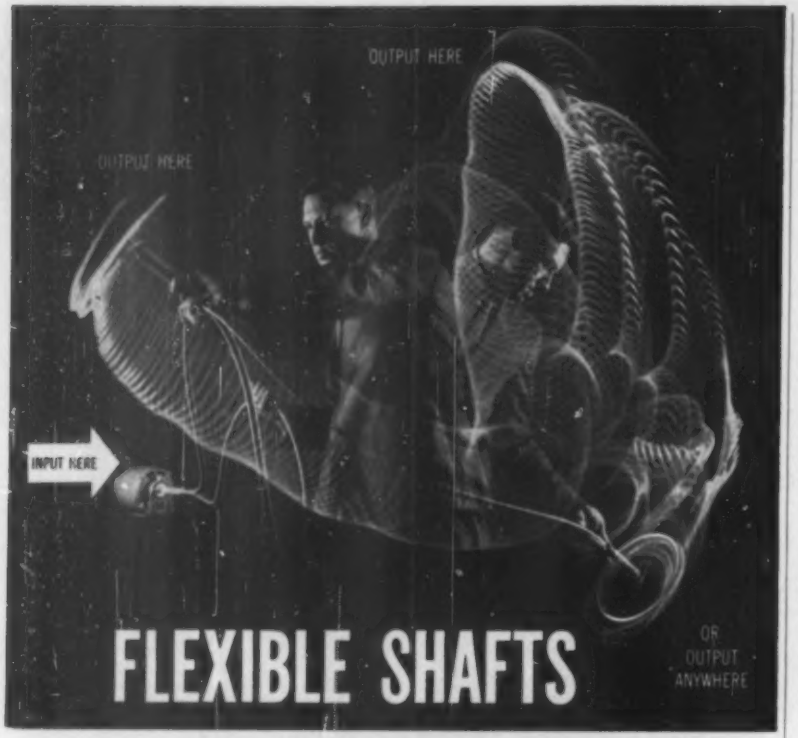
To help solve your specific brake problems, call on Dings complete engineering service.

Write for Bulletin BK4006

DINGS BRAKES, INC.
A SUBSIDIARY OF DINGS MAGNETIC SEPARATOR CO.
4714 West Electric Avenue
Milwaukee 46, Wisconsin

DB-351

Circle 338 on Page 19



put power where you want it

Flexible shafts give the designer important new freedom in transmitting rotary power or control between two points. They enable you to position your power source and your driven part to best advantage . . . without worrying about obstructions, vibration, shock or alignment.

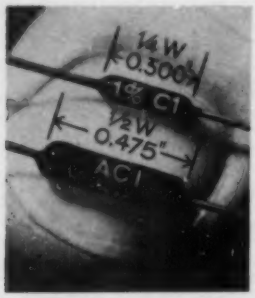
Even if the components are in relative motion to each other, you can still transmit power smoothly and economically.

Flexible shafts also reduce manufacturing costs . . . use fewer parts . . . eliminate cumbersome gears, drives, couplings, universals. With rigid connections gone, alignment and tolerance problems fade away, and installation is a snap.

Whatever your rotary transmission problem, there is a good chance that one of S. S. White's flexible shaft lines can solve it . . . *Standard, Pre-Engineered,* or *Custom-Designed* flexible shafts.

S. S. WHITE INDUSTRIAL DIVISION,
DEPT. 4 10 East 40th Street, N. Y. 17, N. Y.

THE S. S. WHITE FLEXIBLE SHAFT HANDBOOK
New 4th Edition . . . Send for your free copy!



to larger units. Range is from 25 to 500,000 ohms at a standard tolerance of ± 1 per cent. Voltage ratings are 250 and 300, respectively. Temperature coefficient of standard units is ± 100 ppm per deg C. Noble metal film resists oxidation, is impervious to moisture and high humidity conditions, and is unaffected by low temperature and to temperature cycling between −55 and +150 C. **American Components Inc.**, 8th Avenue and Harry St., Conshohocken, Pa.

Circle 657 on Page 19

Thin Welded Tubing

has wall thicknesses from 0.005 to 0.125 in.

Thin-wall, round welded tubing is available in more than 80 grades of corrosion and heat-resisting stainless steels, precipitation-hardening stainless steels, high-temperature alloys, heat-treatable, low-alloy steels, and reactive alloys. Included in the line are many specialized metals such as zirconium, titanium, tantalum, and columbium. Tubing is made in wall thicknesses of 0.125 down to 0.005 in., diam from 1¼ through 36 in. and higher, and lengths to 30 ft. Tubing is also produced in square, hexagonal, rectangular, and flat oval shapes. **Carpenter Steel Co**, Reading, Pa.

Circle 658 on Page 19

Explosive Cartridges

meet all pertinent military specifications

Explosives cartridges provide power to actuate mechanisms such as separation systems, thrust reversal and termination systems, electrical disconnects, parachute and data-package-ejection systems, and other

Computer Analyses Now Make Tenzaloy Better Than Ever

TENZALOY

Asarco has introduced another significant advance in aluminum casting alloy technology — computer correlation of composition and properties of its widely used high-strength, self-aging Tenzaloy. Results: Further refinement in quality and reliable performance of this superior alloy.

Data for the pioneering computer analyses were drawn from a long record of properties and composition of Tenzaloy plant heats compiled by Asarco's Central Research Laboratories. From these studies has come new knowledge of the interaction of Tenzaloy elements and effects of alloying ingredients on mechanical properties.

Computer findings now enable Asarco metallurgists to control Tenzaloy mechanical properties to a much narrower range of variation and to higher average values than ever before — and to reproduce them precisely and consistently over and over. There is only one Tenzaloy and it cannot be duplicated.

TYPICAL PROPERTIES OF TENZALOY

	SAND CASTINGS	PERMANENT MOLD CASTINGS
Tensile Strength	35,000 psi	40,000 psi
Yield Strength	25,000 psi	27,000 psi
Elongation (in 2")	4-5%	6-7%
Brinell Hardness No.	74	74
Impact Strength (Charpy in ft./lbs.):		
Notched	3	3
Un-notched	14	20
Electrical Conductivity	30%	30%

Tenzaloy can widen design horizons, increase production efficiency, reduce costs and improve your products. For your copy of Bulletin 103R5, "Tenzaloy, the Self-Aging Aluminum Casting Alloy," write today to: Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, N. Y.

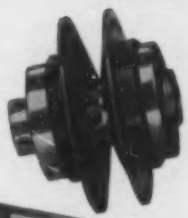
ASARCO

Circle 340 on Page 19

Burroughs B205 computer correlates unique composition and properties of Asarco's high-strength Tenzaloy.

Lovejoy

Precision-Built Variable Speed Pulleys



- Stock delivery from the most complete line on the market—all sizes and types from ¼ to 25 hp., ratios up to 4 to 1 (7 to 1 Hi-Lo).
- Quickly and easily installed.
- Curved pulley faces maintain full belt contact at all speeds and pitch diameters to assure full transmission of rated power and longer belt life.
- Constant belt alignment is maintained by two precision calibrated springs which instantly adjust pulley halves to pitch diameter changes. This prevents side pull and reduces belt wear.
- Every pulley is dynamically balanced to .02 oz.-in. to assure quiet and trouble-free operation.
- Positive lubrication is provided by Alemite fittings on integral hp. sizes and Oilite bronze bushings on fractional sizes.
- *Lovejoy Pulleys outlast equipment life.*

Ask for recommendations on your application. Request Catalog B-61 and prices.

Lovejoy specializes in a full line of easily installed, maintenance-free power transmission equipment:

FLEXIBLE COUPLINGS—any size or type, including specials, .003 to over 8500 hp. Request Catalog A-61.

UNIVERSAL JOINTS—for all industrial applications up to 1750 rpm., .35 to over 450 hp. Request Catalog D-61.

VARIABLE SPEED BELTS—complete line of types and sizes for all applications. Request Catalog C-61.

Motor Bases **Take-Up Frames**

Shaft Mounted Gear Reducers **Variable Speed Transmissions**

Write on your company letterhead or phone for literature and prices.
If you have a specific requirement or problem ask for recommendations. No obligations.

LOVEJOY FLEXIBLE COUPLING CO.

4818 WEST LAKE STREET • CHICAGO 44, ILLINOIS

Telephone EStebrook 9-3010 • Teletype TWX-CG-85

cartridge actuated devices. Design parameters meet all pertinent military specifications and are environmentally qualified. Typical cartridge weighs 14 grams, produces 10,000 psi gas pressure in less than 5 millisec, functions with 0.998 per cent reliability at temperatures of −320 to +500, and withstands 100 g shock loads. **Hi-Shear Corp.**, 2600 W. 247th St., Torrance, Calif.

Circle 659 on Page 19

Water-Based Adhesive

bonds aluminum foil to paper, plastics, other surfaces

Rubbatex water - based adhesive laminates aluminum foil to paper, plastics, and other surfaces. It can be applied by conventional coating machines, flow gun or spray gun, dries transparent, and is nonstaining. For bonding aluminum foil to paper or other porous surfaces, adhesive requires only one-side wet application to form a strong, permanently flexible bond. When laminating foil to plastics and other nonporous surfaces, adhesive is applied to one surface and allowed to dry. When dry, a permanent bond will be formed upon the application of heat. Adhesive is packaged in 55-gal drums and in 1 and 5-gal containers. **Rubba Inc.**, 1015 E. 173rd St., New York, N. Y.

Circle 660 on Page 19

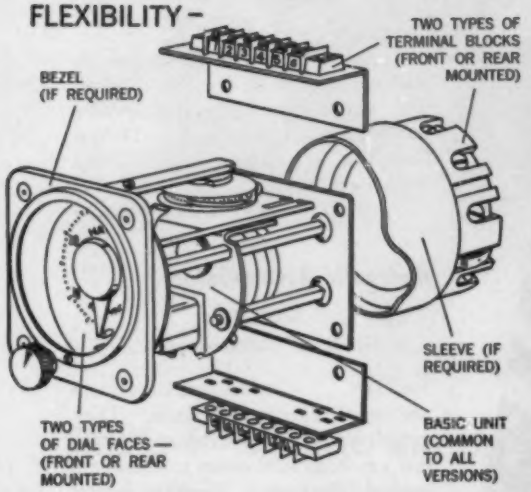
Overload Safety Unit

is easily adjusted to maximum torque load

OSDC unit provides overload protection through use of a basic overload safety device combined with a roller-chain coupling half counterbored to fit the OSD flangs. Standard, double-width roller chain couples the basic OSD unit and the coupling half. Unit automatically disengages when a set maximum load is reached, and is re-engaged

NEW External Clutch Reset ACROTIMER

FLEXIBILITY –


TWO TYPES OF TERMINAL BLOCKS (FRONT OR REAR MOUNTED)
BEZEL (IF REQUIRED)
SLEEVE (IF REQUIRED)
TWO TYPES OF DIAL FACES — (FRONT OR REAR MOUNTED)
BASIC UNIT (COMMON TO ALL VERSIONS)

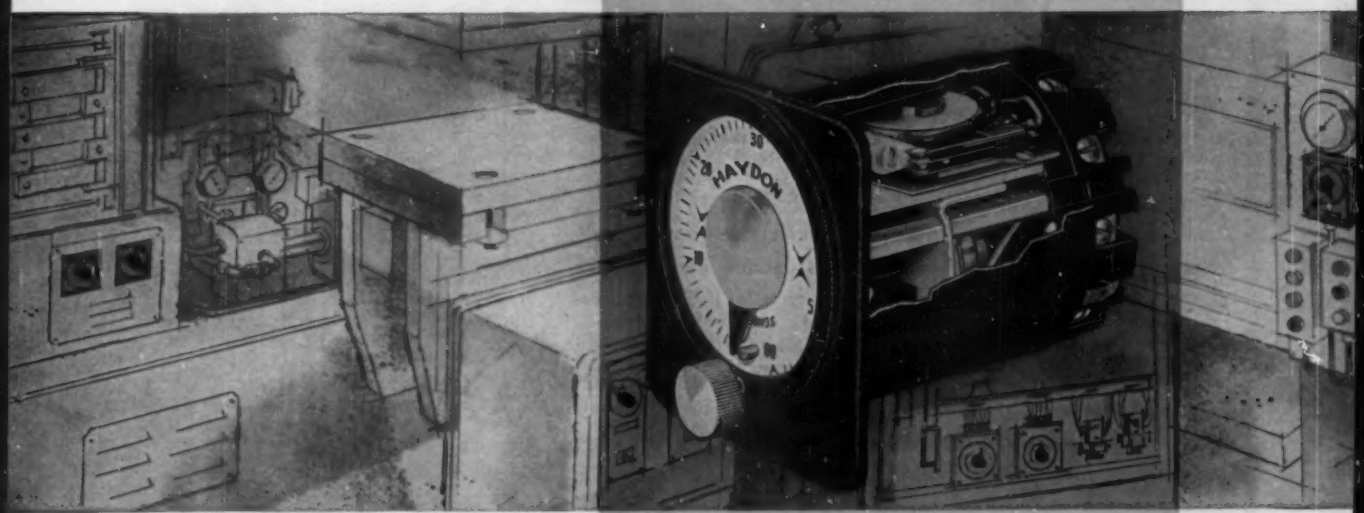
Provides time delay or interval timing, opening or closing one or more switches after an adjustable period of time — and, in addition, offers you these advantages.

EXCEPTIONAL VERSATILITY . . . results from modular construction concept. One basic unit plus easily assembled standard parts provides 12 different variations to meet a very wide range of physical and electrical requirements. Reduces cost, speeds deliveries.

LOWER COST . . . than other units of comparable capacity and quality, because of savings made possible by advanced design and modular construction.

SIMPLE CONSTRUCTION . . . with fewer moving parts. This means greater dependability and contributes to lower purchase price without sacrificing quality and performance.

COMPACT . . . ½" shorter than the next smallest competitive unit and 1" smaller than most competitive units.



Supplied for rear or panel mounting, the ACROTIMER line is designed for operation at 120 to 240 vac, 50 or 60 cycles. Adjustable time ranges from 6 seconds to 4 hours are available. For complete information on these timers, write today for your free copy of the new Haydon ACROTIMER Catalog.

HIGHER RATED LOAD SWITCHES . . . with your choice of one 15-amp or two 10-amp switches.

SPRING-TYPE CLUTCH . . . means negligible wear; longer life; and faster, more positive engagement.

TIMING MOTORS
TIME AND TORQUE CONTROLS

HAYDON

DIVISION OF GENERAL TIME CORPORATION

3134 EAST ELM STREET
TORRINGTON, CONNECTICUT

Circle 341 on Page 19

NEW IDEAS ON ROLLER CHAIN

TO IMPROVE YOUR PRODUCTS... SAVE YOU MONEY

COMPLETE DESIGN IDEA KIT AVAILABLE WITHOUT COST

Want new ideas on how roller chain can help improve your product's design? New application of roller chain to stimulate design ideas? Then here's a gold mine of new applications—the Atlas Design Idea kit.

It is free for the asking. File folder format includes nineteen completely new ways to use roller chain... shown in blueprint form. Shows roller chain as slat conveyor, reciprocating drive, feed roll drive, internal gears, external gears, flexible shaft coupling, rack and pinion table feed, lever actuator and many others.

Write today for your chain idea folder. Another step ahead by Atlas to offer improved products and increase the efficiency of the use of roller chain. Write...

ATLAS CHAIN & MANUFACTURING COMPANY
Subsidiary Prudential Industries
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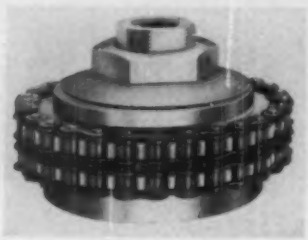
PRUDENTIAL INDUSTRIES
ATLAS



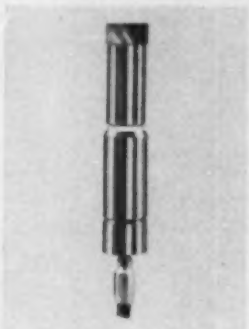
automatically when overload is eliminated. It is easily adjusted with a torque wrench to a specific maximum torque load. **Dalton Gear Co.**, 212 Colfax Ave. N., Minneapolis 5, Minn.

Circle 661 on Page 19

Hydraulic Accumulators

have built-in dashpot to eliminate piston shock

Standard hydraulic accumulators are small, lightweight units. They are all liquid and are designed without gas bags and gases to eliminate possible leakage. Working liquid from the system can also be used. Integral control of flow and pressure meets precise requirements. Built-in dashpot availability eliminates piston shock. Time-delay re-



turns provide flexibility of performance and application of the units using liquid compressibility. Various hydraulic fittings are available to meet system requirements. **Taylor Devices Inc.**, 200 Michigan Ave., North Tonawanda, N. Y.

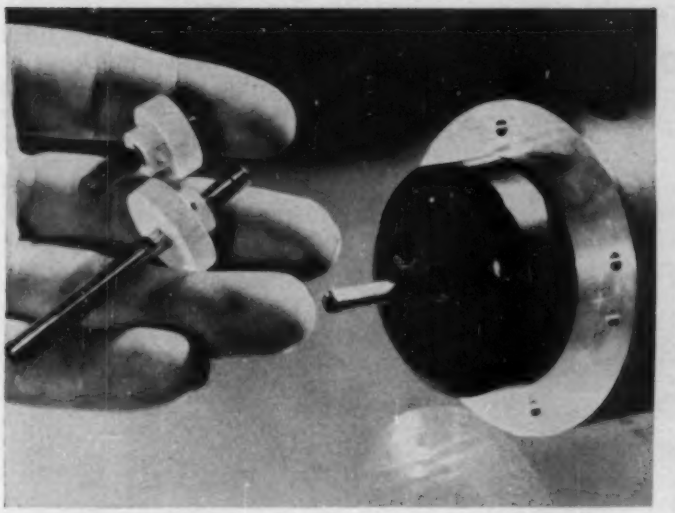
Circle 662 on Page 19

Subminiature Switch

is environment-free unit

Type 65 subminiature, precison snap-action switch is available for use where corrosive atmospheres,

Chemical Division 3M COMPANY



KEL-F® BRAND Plastic keeps gear trains running smoothly...over 14,000 hours without lubrication!

Gears for small electric motors in industrial control instruments are frequently inaccessible for lubrication, but must keep running smoothly and quietly, with lives of at least 10,000 hours. The maker of the ½ inch-ounce motor above —Globe Industries, Inc., Dayton, O.—gets noiseless, self-lubricating gears by machining them from rods of KEL-F Brand Plastic.

KEL-F Plastic was selected because it provides unusual toughness and excellent dimensional stability. It has good frictional properties—resists abrasion and high temperatures. This plastic minimizes thermal expansion, holds moisture absorption to zero so that gears stay within close tolerances and maintain accuracy for the control device. In "life" tests, gears of KEL-F Plastic ran for over 14,000 hours without evidence of wear!

Now available is an improved form of this material, new KEL-F Brand 81 Plastic. For further information on its many mechanical, chemical and dielectric features, read "profile" at right, then return coupon, below.

Chemical Division, Dept. KCG-101
3M Company, St. Paul 6, Minn.

TELL ME MORE
about new KEL-F 81 Plastic

Name_____
Title_____
Company_____
Address_____
City & State_____

PROPERTIES PROFILE
ON
KEL-F® BRAND 81 PLASTIC

KEL-F 81 Plastic combines great dielectric and mechanical strength with exceptional thermal and chemical stability. It may be used in a variety of forms in such design fields as aerospace, chemical processing, electronics and many others.

Electrical Properties (Crystalline)

	Dielectric Constant	Dissipation Factor
100 cycles, 25°C.	2.63	.0617
10,000 cycles, 25°C.	2.45	.0216
100,000 cycles, 25°C.	2.40	.0143
100 cycles, 120°C.	2.69	.0041
100 cycles, 150°C.	2.74	.0048

Electrical Strength in Oil (Amorphous)

Caliper—.015 in.
2" electrode . . . 1010 vpm

Surface resistivity— $> 10^{18}$ ohms

Volume resistivity—4×10^{16} ohms/cm

KEL-F 81 Plastic provides zero moisture absorption—minimizes surface flash-over. Arc resistance is greater than 360 seconds.

Physical Properties (Crystalline)

Tensile strength	4900 psi
Impact strength	3.1 ft. lb./in. of notch
Compressive strength (0.2% offset)	5440 psi
Modulus of elasticity (tensile)	186×10^3 psi
Shear strength	5440 psi
Operating range	—400 to +400°F.

In addition, KEL-F 81 Plastic is unaffected by most corrosive media—resists organic solvents, strong caustics, oxidants, missile fuels, concentrated acids, even fuming nitric.

This plastic is readily molded by standard equipment by injection, compression, extrusion or transfer methods. Parts may be machined to close tolerances—may be drilled, punched, polished, buffed or sanded as required.

For added technical information about KEL-F 81 Plastic, return coupon, or write 3M Chemical Division, describing your area of interest.

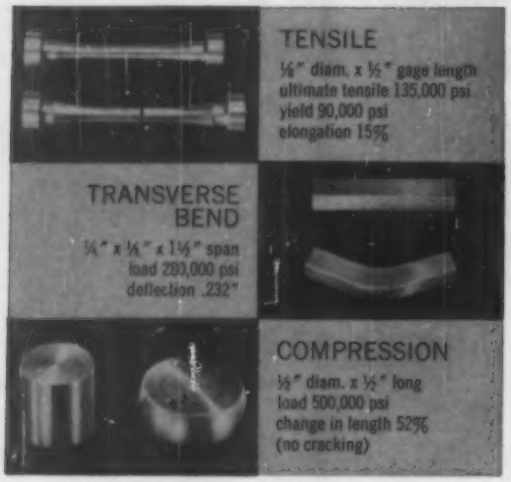
"KEL-F" is a reg. TM of 3M Co.

MINNESOTA MINING & MANUFACTURING CO. 3M

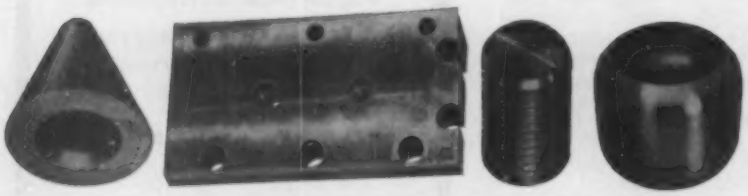
Circle 343 on Page 19

KENNERTIUM*

exceptional properties solve unusual problems



THESE TYPICAL PARTS INDICATE THE EXCELLENT MACHINABILITY OF KENNERTIUM



Kennertium, a new heavy tungsten alloy 50% heavier than lead, offers a number of outstanding properties not available in other high-density alloys on the market today.

These superior features include high tensile strength; elongation 15% or higher; unusual compression qualities; Young's Modulus of Elasticity of 45,000,000 psi; plus good machinability and other properties to help designers meet many exacting materials requirements.

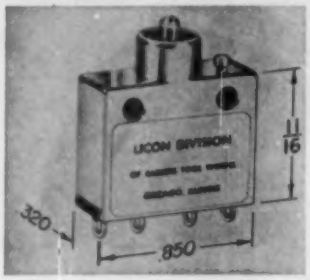
Kennertium is available in virtually any configuration—and in solid sections up to 16 inches in diameter and 20 inches long for machining to required parts. Cylinders several feet long, or thin rings up to 18 inches in outside diameter, can be processed.

For more information, write for "Kennertium Properties" booklet. And if you have a specific requirement, send dimensional sketch and conditions involved. Our engineers will gladly make recommendations, without any obligation to you. KENNAMETAL INC., Dept.MD, Latrobe, Pennsylvania. *Trademark

3001C

INDUSTRY AND KENNAMETAL ...Partners in Progress

excessive moisture, temperature extremes, or foreign particles and liquids threaten reliable switch performance. Rated at 10 amp, 30 v dc, 120 v ac, unit measures 0.320 x 0.850 x 11/16 in. Switch can be side mounted with No. 4 screws; threaded bushings permit one-hole panel mounting. Range of integral actuators is available, including pin plunger (shown), overtravel plunger, rigid lever, and roller-lever. Unit has two, three, or four terminals, or wide choice of potted leads. **Licon Div., Illinois Tool Works,** 6615 W. Irving Park Rd., Chicago 34, Ill.



Circle 663 on Page 19

Oil-Resistant Coating

permits use of rubber as vibration mount

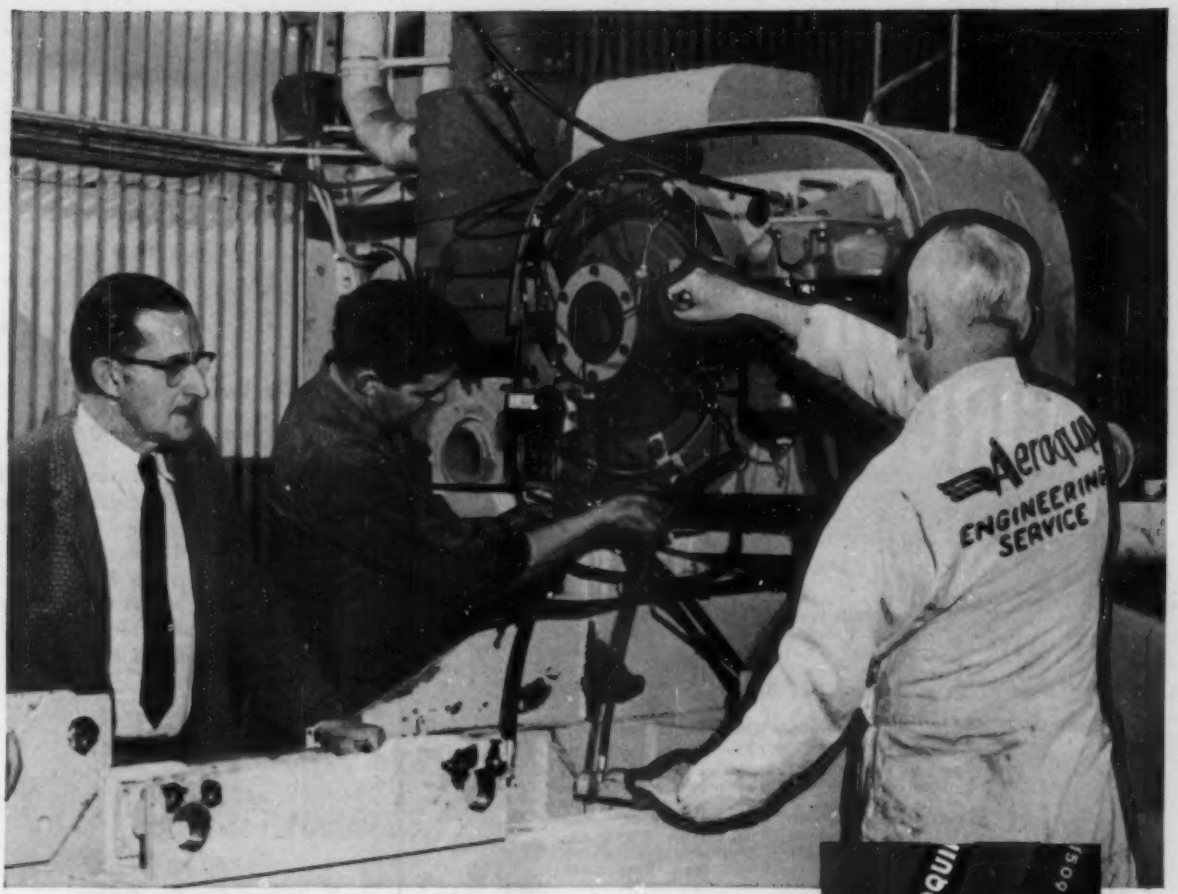
New organic coating, Iso-Kote, protects natural rubber from the destructive effects of diester and other lubricants, and will permit new vibration-isolating mount and related applications for natural rubber. Material is effective against most solvents and petroleum-base fuels and lubricants, especially diester lubricants. Coating exhibits low permeability to these lubricants, has good adhesion to rubber, is flexible to −65 F, and has a tensile strength of 550,000 psi. It exhibits a minimum 300 per cent elongation without cracking, and has excellent abrasion resistance. **MB Electronics,** P. O. Box 1825, New Haven 8, Conn.

Circle 664 on Page 19

Acrylic Sheet

is tough, craze resistant

Tuffak molecularly-oriented acrylic sheet combines outdoor weathering



Aeroquip Fluid Piping Service Can Solve Production Problems

Aeroquip's unique Fluid Piping Service can be of valuable assistance to major equipment manufacturers in the production stage. Experienced Aeroquip sales engineers, working closely with production people in your plant, help simplify ordering, expediting, stocking and processing procedures. They can check installation and routing techniques, working right on the assembly line to instruct your personnel in proper procedures.

Production assistance is only part of Aeroquip's start-to-finish fluid piping service. Highly qualified Aeroquip engineers can also work with you throughout the design, prototype testing, parts programming and field service stages. Within this broad scope of service, Aeroquip accepts full responsibility for fluid piping performance.

Call your Aeroquip sales engineer for full details, or write to us.

Aeroquip fluid piping specialists can work with you in every phase of manufacture to assure maximum performance of fluid piping systems on your products.

Aeroquip now produces a wide range of fluid piping products, including hose assemblies with standard or special tube configuration fittings, Self-Sealing Couplings and a full line of adapters and tube fittings.

Aeroquip

AEROQUIP CORPORATION • JACKSON, MICHIGAN
INDUSTRIAL DIVISION
INDUSTRIAL PLANTS: VAN WERT, OHIO; BURBANK, CALIFORNIA; DALLAS, TEXAS; PORTLAND, OREGON; CRANBURY, NEW JERSEY
In Canada: Aeroquip (Canada) Ltd., Toronto 19, Ontario
In Germany: Aeroquip G.m.b.H., Baden Baden-Oos
AEROQUIP PRODUCTS ARE PROTECTED BY PATENTS IN U.S.A., CANADA AND ABROAD

Circle 345 on Page 19

NOPAK OFFERS YOU COMPLETE AIR CIRCUITRY

another Plus Value by NOPAK

NOPAK "V"

NOPAXAM

NOPAK-MATIC

The addition of Nopaxam palm button, cam, lever and air operated valves "closes the Nopak circuit." Precise control — mechanically or electrically signaled — can now be *completely* Nopak. Singularly or in combination, Nopaxam, Nopak "V" valves and Nopak-matic valves will meet your most complex circuit requirements.

Nopak "V," 4-Way, Pilot Operated Slide Valves

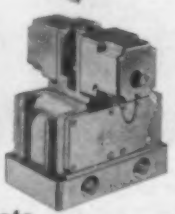
For direct or remote control. Either single or double air pilot or solenoid actuated. Simple, proven design, durable construction insure trouble free operation. See Catalog 102-A.

Nopaxam Precision Spool Valves

For air or hydraulic service to 150 psi. Pilot or mechanically operated, these valves are small, compact, easily mounted, have extremely short throw and high flow rates. See Catalog N.

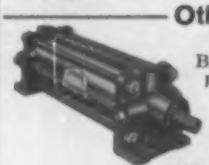
NOPAK-MATIC Poppet-Type, Pilot Operated Valves

Fast acting, high volume air valves from ¼" to 1¼" with master (air piloted), single or double solenoid. Side or bottom ported subplates or manifolds. Removing cover plates affords easy access to piston poppets housed within removable, interchangeable cartridges. 100% J.I.C. See Catalog 105.



Other NOPAK "CVA*" Products

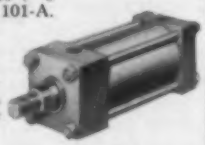
NOPAK Class 1 Cylinders



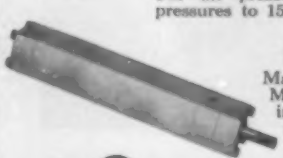
Brass Tubing and Tie-Rod Construction. For pressures to 250 psi. Choice of adjustable cushion, self-regulating or non-cushion heads. Diameters from 1½" to 16". 6 Standard Mountings. See Catalog 101-A.

NOPAK Class 6 Bore-Rated Cylinders

Compact steel plate, square head with tie-rod and honed steel tubing construction. For air pressures to 250 psi. hydraulic pressures to 1500 psi. See Catalog 106.



NOPAK Class 7, Square Barrel Cylinders



Made with pressure-cast and extruded aluminum. Mounting holes can be drilled or tapped directly into cylinder tubing. ¾" to 3" bores pressure rated for 200 psi. air or 1000 psi. oil. 7 universal mountings. See Catalog 107.

*CVA Cylinders, Valves, Accessories
NOPAK offers a complete line of Matched Fluid Power Components.

NOPAK VALVES & CYLINDERS

NOPAK DIVISION
Galland-Henning Mfg. Co.
2752 S. 31st St., Milwaukee 46, Wis.

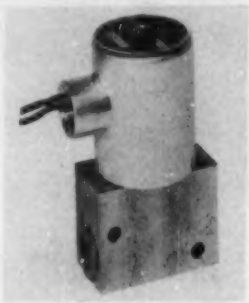
properties of Plexiglas acrylic sheet with specific characteristics. Properties include punchability, flexibility, and excellent toughness and craze resistance. Material is available as colorless sheet in 42 x 42 and 84 x 84-in. sheets, in 0.050-in. thickness. **Rohm & Haas Co.**, Washington Square, Philadelphia 5, Pa.

Circle 665 on Page 19

Solenoid Valves

for oil pressures to 3000 psi

Two-way solenoid valves for oil pressures to 3000 psi are available in normally open and normally closed types. Both are pilot-operated, poppet-type valves in cartridge form. They can adapt to any type of manifold or subplate. All standard ac or dc solenoids are inter-



changeable. Poppet and plunger are the only two moving parts. All valves have free reverse flow in either energized or de-energized position. **Fluid Power Accessories Inc.**, Box 64, Glenview, Ill.

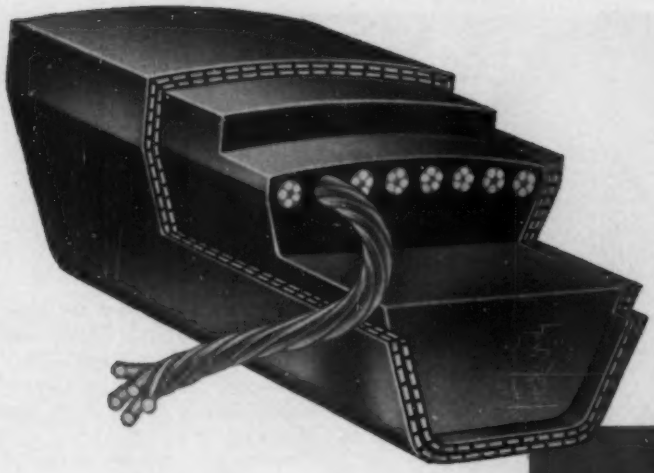
Circle 666 on Page 19

Miniature Switch

incorporates two snap-action units

Miniature switch has two snap-action switches ganged on a panel, applicable to a space of 1 x 1 x 1¼ in. They can be operated individually or simultaneously from two directions. Actuator permits linear, rotary, or rotary-cam operation without the use of auxiliary actuators. Actuator arm has a built-in overtravel stop to prevent switch damage and to provide for high electrical and mechanical switch life. Overtravel of 0.125 in. mini-

Circle 346 on Page 19

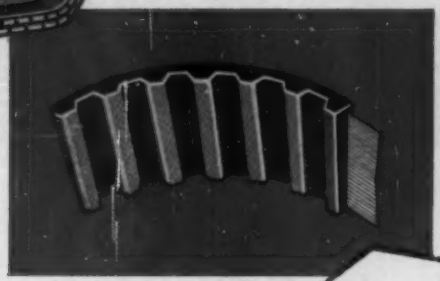


Need High Capacity In Compact Space?

DA 3S8 V-BELTS. This major design improvement in V-Belts brings you unprecedented compactness, high capacity and drive economy.

Chain and Gear Benefits with No Metal-to-Metal Contact?

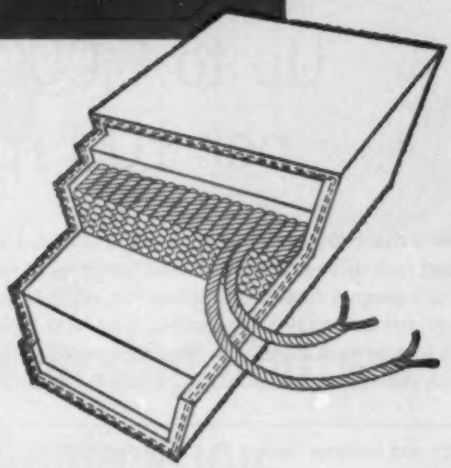
DA POSITIVE DRIVE BELTS. Revolutionary tooth-grip principle; no stretch; no constant lubrication. Highly versatile.



Whatever your V-Belt needs, DURKEE-ATWOOD *meets them*

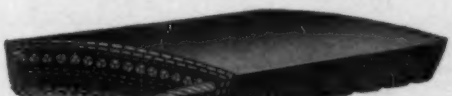
What do you want in a V-Belt? You want consistent performance, long trouble-free life and full-rated power transmission. That means the belts must be made of the finest quality materials, with careful attention to engineering details, manufacturing processes and testing procedures. Durkee-Atwood V-Belts are made of the newest high tenacity synthetic fibres to assure length stability in storage. The exclusive Durkee-Atwood "Iso-Dynamic" Vertical Matching Machine eliminates the "sag error" that develops when V-Belts are matched on horizontal equipment. This assures equal power transmission from all belts on multiple drives . . . Look to Durkee-Atwood for *quality, service* and *savings* ...*the most complete line of industrial V-Belts.*

Look for the DA *On Your V-Belts*



40% Extra Capacity in Regular V-Belts?

RED SHIELD MULTIPLE V-BELTS. Increased capacity at no increased cost. Available in oil and heat resistant and static dissipating constructions.

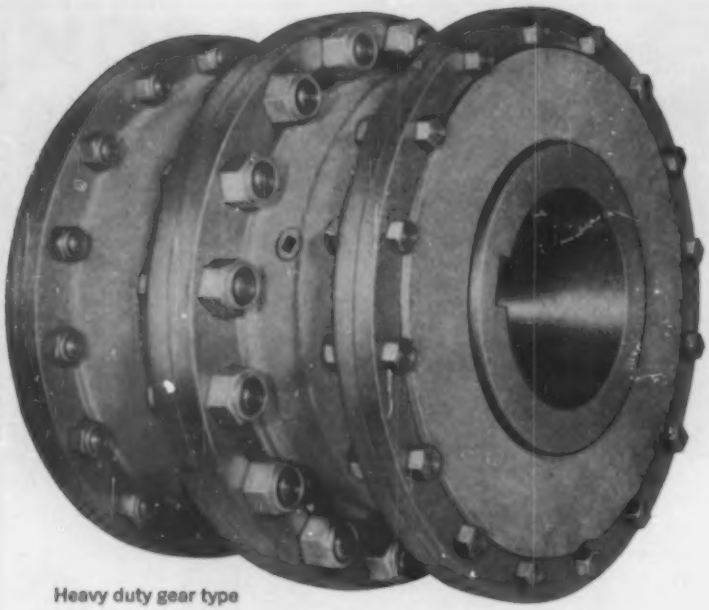


Top Performance in Variable Speed Drives?

VARIABLE SPEED BELTS. For constant performance. Abrasion-resistant cover; crowned cross section maintains stability under extreme loads.

DURKEE-ATWOOD V-BELTS

DURKEE-ATWOOD COMPANY MINNEAPOLIS 13, MINNESOTA



Heavy duty gear type

Up to 6,000 hp per 100 rpm

Here's the coupling with all the muscle you need for heavy duty slow speed mill drives. The machined surfaces of each high grade steel casting are given a fine tool finish within strict tolerances. Waldron mill type couplings are easy to assemble, and seal tight against dust, moisture, and loss of lubricant. The standard sizes listed below are available for quick delivery. Write for Data Sheet S-1050.

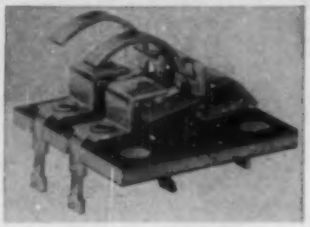
Size and nominal bore	HP/100 rpm	Max. rpm
7	1,282	1,950
8	1,912	1,720
9	2,662	1,550
10	3,675	1,400
11	4,950	1,275
12	6,000	1,200

WALDRON-HARTIG, Box 791, New Brunswick, N. J.
a division of Midland-Ross Corporation MR

WALDRON
Makes it easy to pick the right

Couplings

Circle 348 on Page 19



mum eliminates the need for close tolerance cam designs. Ratings are 10 amps, 125 v ac; 5 amps, 250 v ac; and ⅓ hp, 125/250 v ac. **Cherry Electrical Products Corp.**, P. O. Box 66, Highland Park, Ill.

Circle 667 on Page 19

Modified Polypropylene

has high rigidity and heat-distortion values

Oleform modified polypropylene is available in experimental quantities for applications requiring toughness and rigidity over a wide temperature range. Properties include high rigidity and heat-distortion values, excellent dimensional stability and creep resistance, good chemical resistance, and low moisture absorption. **Avisun Corp.**, 1345 Chestnut St., Philadelphia 7, Pa.

Circle 668 on Page 19

Magnet Material

has coercive force of 1400 oersteds

Alnico VIII permanent-magnet material has the highest coercive force of all the Alnicos, 1400 oersteds, combined with a low temperature coefficient. Material has an energy product of 4.2 million, and will have use in applications where very short magnet lengths are desired. **Indiana Steel Products Div., Indiana General Corp.**, Valparaiso, Ind.

Circle 669 on Page 19

Carbon Potentiometer

operates at temperatures to 150 C.

Carbon Trimpot potentiometer, Model 3001, only ¾ in. long, is designed for high packaging density. It has high temperature and moisture stability. Resiston carbon ele-

No Matter Where You Install Them—

Bulletin 705 Reversing Starters are available in seven sizes. Maximum ratings: 100 hp, 220 v; 200 hp, 440-550 v.

The New Allen-Bradley Reversing Starters are "Ideal" for the Application

Whether you're using the "open type" Bulletin 705 reversing starters in special panel mounting or as an enclosed device for mounting on a machine, the space you can save will surprise you—especially in the higher ratings! For instance, the open type construction is appreciably narrower than the older design. In the enclosed design—because the overload relays (either 2 or 3) are mounted as a "block" below the reversing switch, the cabinet is much narrower.

There is no denying that the new A-B Bulletin 706 reversing starter is the best "buy" on the market today. Rating for rating, the old reliable Bulletin 705 reversing switches can no longer be compared with their successors. While the simple one-moving-part solenoid principle of operation has been retained, the detail design and construction has been greatly improved. The result is *extra* life that assures almost unbelievable reliability.

The new, attractive enclosures add extra "eye appeal" to any installation. For full details, please write today for Publication 6100: Allen-Bradley Co., 1333 South First Street, Milwaukee 4, Wisconsin.

ALLEN-BRADLEY

Member of NEMA

QUALITY MOTOR CONTROL

Circle 349 on Page 19

ment, a high-temperature carbon deposited on an inert and moisture-proof ceramic base, enables unit to operate at temperatures to 150 C and under cycling humidity conditions with resistance shift of one-half that of other carbon units. Power rating is 0.2 at 70 C. **Trimpot Div., Bourns Inc.**, 6135 Magnolia Ave., Riverside, Calif.

Circle 670 on Page 19

Acrylic Molding Powder

has extremely high impact strength

Implex R acrylic molding powder provides double the highest impact strength previously available in Implex acrylics. It has a high degree of transparency in natural color, and is available also in a wide range of standard colors for injection molding or the extrusion of sheets and shapes. Material contains no plasticizers, is dimensionally stable, low in water absorption, resistant to staining and attack by many chemcals, corrosion-free, and free of odor or taste. Parts molded can be cut, drilled, machined, and solvent-cemented; surfaces can be decorated by spray painting, engraving, printing, hot stamping, silk screening, and vacuum metallizing. Five formulations are available. **Rohm & Haas Co.**, Washington Square, Philadelphia 5, Pa.

Circle 671 on Page 19

Silicone Rubber

for use from −80 to +500 F temperatures

Silastic 241U is an easy-processing silicone rubber which meets 40 durometer requirements of military specifications. Soft and nontacky, material has good green strength, bands readily on mill rolls without crumbling, and requires very little mill softening. Finished parts can be manufactured by molding, extruding, or calendering; shrinkage during manufacture is low. Suitable for use from −80 to +500 F, rubber retains physical strength and flexibility after long exposure to temperatures in this range. Electrical properties are good and compression set is low. **Dow Corning Corp.**, Midland, Mich.

Circle 672 on Page 19

Sealed Potentiometer

has wiper assembly within control knob

Cap-Pot sealed potentiometer is wire-wound, rated at 0.5 w, and is available in linear functions to 10,000 ohms. Wiper assembly is

Specifying LAMINATED PLASTICS...as sheet,

TAYLOR FIBRE CO. BELONGS IN YOUR SPECIFICATIONS

Taylor has the products... offers more than 50 grades of industrial laminated plastics . . . including paper, cotton cloth, nylon, asbestos, glass cloth, or other base material impregnated with phenolic, melamine, silicone or epoxy resins and formed into sheets, rods and tubes under heat and pressure. Also a number of composite materials, including copper-clad laminated plastics, vulcanized fibre and laminated plastics, rubber and laminated plastics, asbestos and laminated plastics, and aluminum and laminated plastics.

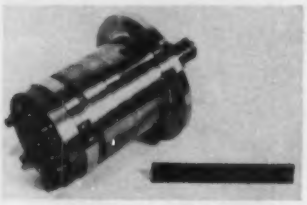
Use this Taylor Selection Guide to make selections of the Taylor laminated plastics that will fit your requirements.

mounted within the control knob, requiring minimum space behind panel and permitting installation on pressurized equipment without bellows bushings. An O-ring is incorporated to provide panel sealing. Unit is waterproof, dustproof, explosion, and corrosionproof. It has a diameter of ½ in. **Clarostat Mfg. Co. Inc.**, Dover, N. H.

Circle 673 on Page 19

Liquid Pumps

for pressures to 3000 psi



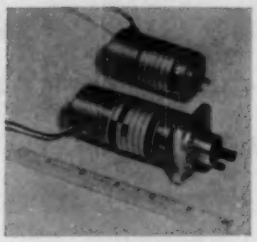
New pumps handle H_2O_2 and other liquid monopropellants and fuels. They provide delivery rates from 0.1 to 20 gpm at pressures to 3000 psi. Design is a multicylinder swashplate, with a common driven valve. Pumps provide volumetric efficiencies of better than 95 per cent over their operating range. Consistency of delivery characteristics permits a gang of pumps to be used for metering in complex liquid-fuel systems. Pumps range is displacement from 0.2 to 1 cu in.; they are suitable for service to 6000 rpm. Sizes range from 6 to 7½ in. long and 3½ to 5½ in. diam; weights range from 6 to 30 lb. **Clevite Ordnance Div., Clevite Corp.**, 540 E. 105th St., Cleveland 8, Ohio.

Circle 674 on Page 19

Wound-Field Motors

are specifically wound for the application

Type GJ wound-field dc motors have 1⅜-in. diam and are furnished in two basic ratings: Type GJA is 3 in. long and is rated 1/50 hp at 10,000 rpm; Type GJY is 2½-in. long and is rated 1/100 hp at 10,000 rpm. Both versions are normally furnished split series for three-wire reversibility with SPDT switch. Motors can be fitted with integral brake or governor, and a planetary gear reducer with choice of 101 standard



gear ratios. Type GJ motors are specifically wound for the application and can be furnished as split series, shunt, or split shunt. **Globe Industries Inc.**, 1784 Stanley Ave., Dayton 4, Ohio.

Circle 675 on Page 19

Plug Valves

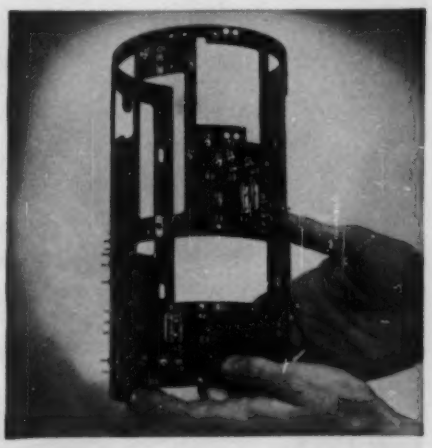
have high-lubricity plastic coating on tapered surfaces

Permaturn tapered plug valves handle services ranging from jet fuels and chemicals to water and sewage. High-lubricity, 0.0005-in. plug coating is applied to tapered surfaces. For low-pressure valves, for

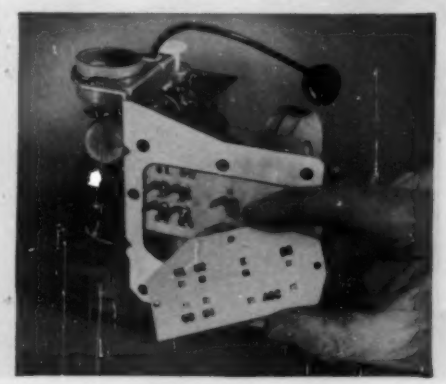
rod, tube or fabricated parts?

Taylor has the facilities. Its Norristown, Pa., plant, comprising some 300,000 sq. ft., produces both laminated plastics and vulcanized fibre . . . is one of the most completely integrated in the industry . . . even makes its own paper and a large percentage of its own resins. The La Verne, Calif., plant, with over 45,000 sq. ft. of floor space, specializes in the manufacture of laminated plastics for the convenience of West Coast customers. And both plants can fabricate parts from any Taylor materials to specifications, economically.

Taylor laminates offer many advantages over metals. They have a higher strength-to-weight ratio, are corrosion resistant, and can be fabricated more easily. This Taylor Selection Guide will help you evaluate the different grades available. Write for your copy today. Taylor Fibre Co., Norristown 47, Pa.



For applications requiring high strength retention at elevated temperatures, Taylor Grade GEC—an epoxy resin, glass fabric base material.



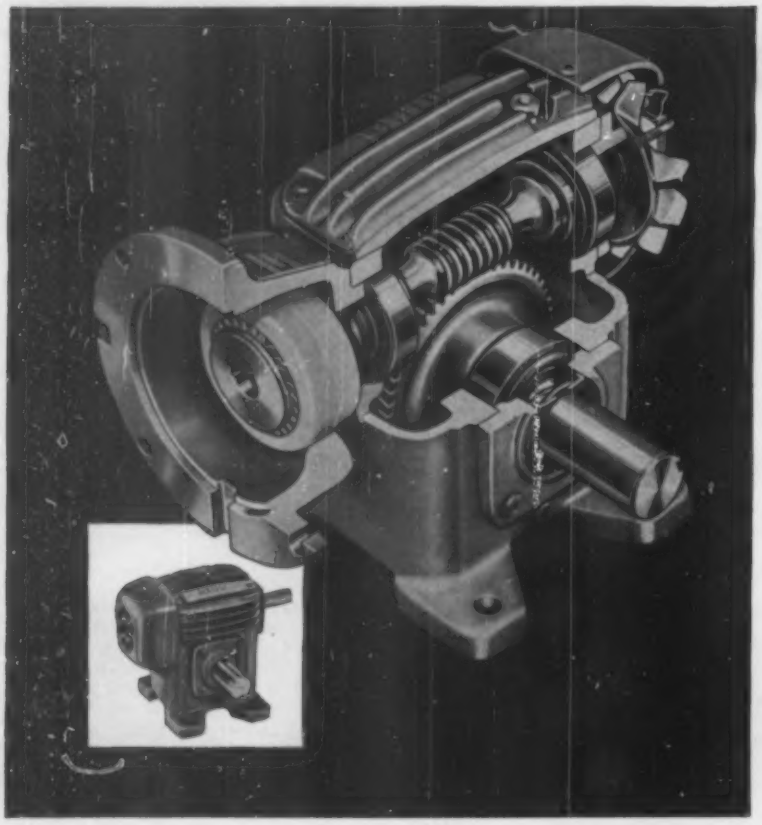
For high-temperature electrical applications and high-frequency radio equipment, Taylor Grade GSC—a silicone resin glass fabric base material. Has high heat resistance, excellent electrical properties, and high arc resistance. Will not support combustion.

Taylor

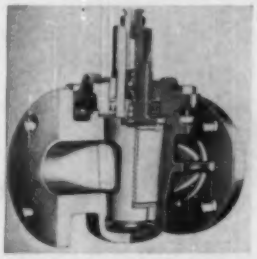
LAMINATED PLASTICS VULCANIZED FIBRE

Circle 350 on Page 19

Get 80% more capacity in 25% less space with OHIO LINE... industry's most modern line of speed reducers. OHIO LINE reducers are available in more than 350 standard models and sizes—available for fast delivery from local stocks in 63 strategic points throughout the country. Write for a complete 246 page catalog: Ohio Gear Company, 1302 E. 179th St., Cleveland 10, Ohio



pressures to 1000 psi, coating is Teflon; for high-pressure services to 10,000 psi, coating is phosphate-molybdenum disulfide. Both coatings are permanently bonded to the metal surfaces. Fixed adjustment assembly used on low-pressure valves maintains a constant, tight seal after repeated openings and closings and facilitates uniform turning ease. Threadless stem used in high-pressure valves results in a reduction of



the high operating torques of conventional high-pressure valves. Single, quarter-turn operation permits full opening and closing with one 90-deg turn. **Meter & Valve Div., Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh 8, Pa.**

Circle 676 on Page 19

Bondable Fluorocarbons

permit bond strengths to 55 lb per in. peel strength

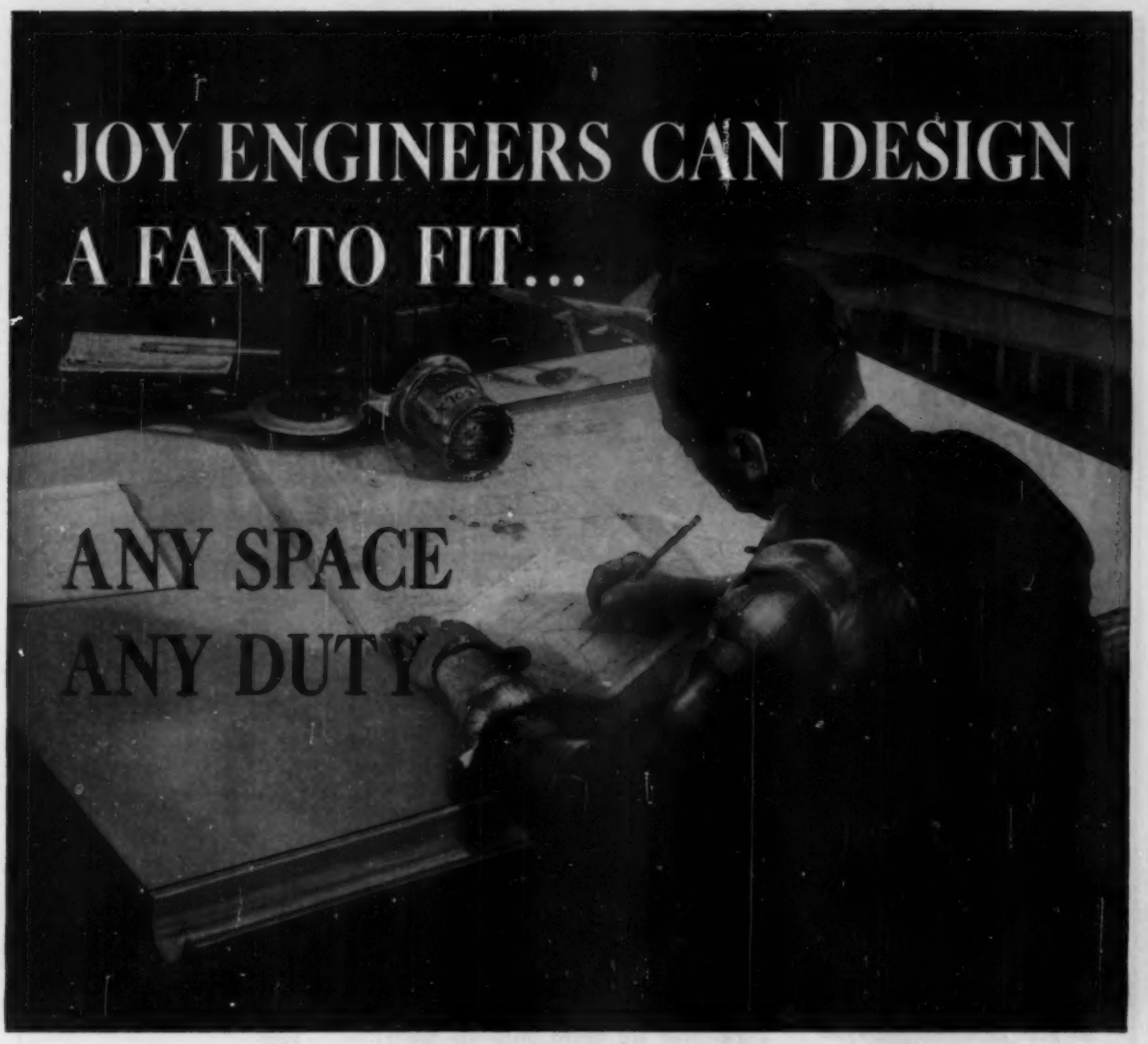
Etching Teflon or Kel-F with Fluorobond solution permits ordinary adhesives to bond these hightemperature plastics to glass, ceramics, all fabrics, plastics, rubber elastomers, steel, aluminum, copper, and other metals. Bond strentghs as high as 55 lb per in. peel strength are obtained. **Joclin Mfg. Co., Lufbery Ave., Wallingford, Conn.**

Circle 677 on Page 19

Clutch-Brake Package

for fhp duty-cycle use

Prealigned Electro-Pack clutch-brake package for fractional-horsepower duty-cycle applications combines an electric clutch and an electric brake as a preassembled unit, with input and output shaft extensions, ready to bolt in place and hook up to the power source. Drive can be offset-coupled through gears, belts, or chains, or in-line mounted

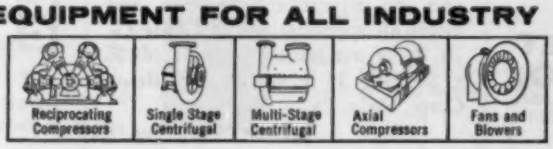


In many cases the primary requirement for cooling or ventilating fans is that they fit into whatever space remains after the major equipment components have been positioned. Length, width, height, weight . . . any one or all may be critical.

Joy engineers have developed hundreds of fans to meet specific dimensional requirements while delivering air at the required pressure and volume. Performance may be achieved with centrifugal, axial-flow, or mixed-flow designs, providing either fixed duty point or broad operating range performance characteristics. Depending upon application requirements, basic construction may be either cast or sheet metal type fabrication.

Whenever you have an air moving problem, consult your Joy representative. Most requirements can be met economically from the hundreds of stock models available. If a special fan is necessary, Joy will provide an efficient, economical design. For full details on Joy fans, write for Bulletin 2555-64B.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY



JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

Circle 352 on Page 19

between drive and driven shafts. Three sizes are rated 10, 60, and 240 lb-in. static torque for maximum shaft speeds of 10,000, 7500, and 5000 rpm. **Warner Electric Brake & Clutch Co.**, Beloit, Wis.

Circle 678 on Page 19

Silicone-Rubber Base

for temperatures from −120 to +450 F

KW-1920 silicone-rubber base compound combines low temperature flexibility with good resistance to oils and other fluids. Base can be compounded into silicone-rubber stocks for making seals, diaphragms, and gaskets. Silicone-rubber compounds fabricated from the base have useful temperature range of −120 to +450 F, and low shrinkage. **Silicones Div., Union Carbide Corp.**, 270 Park Ave., New York 17, N. Y.

Circle 679 on Page 19

Epoxy Adhesive

is two-part material which does not shrink or expand

Two-part epoxy adhesive is available in air-tight, collapsible-metal tubes. It can be used with metal, wood, plastic, glass, china, tile, and other items. Material consists of an epoxy resin and a hardener in fold-up metal tubes with plastic spreader caps. Equal parts of the resin and hardener are mixed until the mixture turns gray; it is then ready to be applied. Adhesive will not shrink or expand and is waterproof. **Permacel Div., Johnson Inc.**, New Brunswick, N. J.

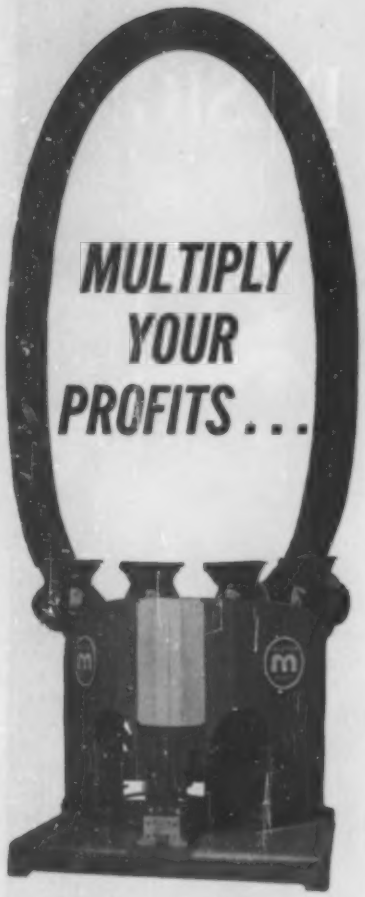
Circle 680 on Page 19

Copper-Clad Laminate

has high hot-peel strength

Grade G-10R copper-clad laminate for printed circuitry delivers a peel strength of 9 to 11 lb per in. of width at room temperature, and 2 to 4 lb per in. of width at 500 F, using 2-oz copper foil, measured on 1/16 and 1/8-in. widths. Material uses no structural adhesives and meets all specifications of Grade G-10. It is available in sheets of 36 x 36 and 36 x 48 in. **Synthane Corp.**, Oaks, Pa.

Circle 681 on Page 19



with MILFORD "MULTIPLES!"

The "Multiples" that keep assembly costs down while increasing production and profits are standard Milford rivet-setting machines operating as a unit. The Milford line is designed as "building blocks" for multiple units to suit your automatic riveting needs. They can be flexibly regrouped to meet the next, low cost assembly requirement.

The narrow wedge shape of Milford's No. 56 and 57 permits grouping to set rivets head to head and, when grouped, **the cost of labor and burden is divided by the number of heads in the unit.** Write for Milford's Engineer's Kit, so you can explore the profit multiplying possibilities of Milford "Multiples" first hand. *Or we'll be glad to quote on your needs immediately.*

THE MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • HATBORO, PENNA.
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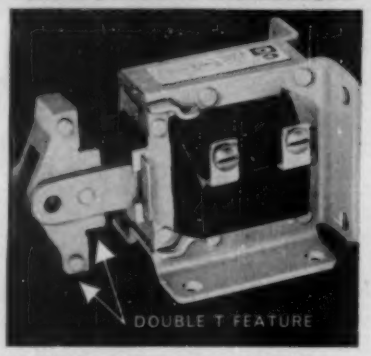
Circle 353 on Page 19

NEW DOUBLE T INDUSTRIAL SOLENOID



Delivers Greater Pull, Faster Cycling, Longer Life

The new 831 series of industrial solenoids designed by Controls Company, the world's largest manufacturer of laminated solenoids, will even out-perform many solenoids of larger size. Check these features:

- Double T plunger provides level pull characteristics with no power drop-off at 2/3 stroke.
- Epoxy encapsulated coil is impervious to water, oil, acid or alkalies.
- Hard chrome plated, beryllium copper core guides assure increased life.
- Heavy coat of epoxy paint on frame and core provides added protection against environmental conditions.
- Universal mounting bracket permits mounting in any position.
- Plunger has reinforced linkage design providing maximum bearing surface.

To learn how you can have improved solenoid performance at lower cost, write for Industrial Solenoid Bulletin SL-33 containing pull curves, specifications and performance facts. A complete line of commercial grade solenoids is also available. For information, ask for *Commercial Solenoid* Bulletin SL-23.

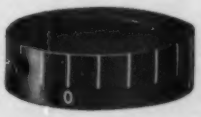
CONTROLS COMPANY OF AMERICA

APPLIANCE AND AUTOMOTIVE DIVISION
9555 SORENG AVENUE
SCHILLER PARK, ILLINOIS

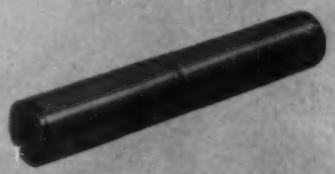
Circle 354 on Page 19

TEN CASE HISTORIES SHOW YOU HOW TO LOWER COSTS, SPEED PRODUCTION, IMPROVE PRODUCTS WITH RICHARDSON FABRICATED PARTS

1 Noiseless aircraft gear provides strength, light weight, close tolerances, and eliminates electric shorts or possibility of leaks, reduces costs. Made of INSUROK® T-827.



2 This piece replaces steel adjusting collars, speeds up press time, provides clearer markings, will NOT rust, saves $8.35 per piece. INSUROK T-615 was used.



3 Fabricated tube ends duplicating machine problems by resisting developing solutions at less cost than stainless steel or other plastics. INSUROK T-303 and T-643 were used.

4 Laminated firing pin eliminates cracking during close tolerance machining, cuts production costs $10.00 per thousand, reduces scrap losses. INSUROK T-643 worked perfectly.

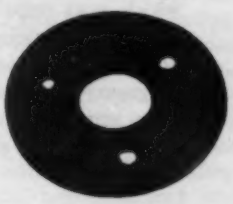
5 Substantially lower priced, easier on products, star wheel replaces and outlasts metal or rubber types, acts as safety device. Made from INSUROK T-601.

6 Close tolerance fabricated control plate terminal provides clearer markings, is uniform in quality, saves customers $1200 per year. INSUROK T-814 solved the problem.

7 Safer laminated tube motor brush holder replaces nylon type because of lower moisture absorption, greater strength and insulation properties. INSUROK TR-303 did the job.

8 This road grader pivot bearing stands up where metals fail, is self-lubricating, provides rugged long life, trouble-free service. Made from graphitized INSUROK T-602.

9 Color-coded sign spacers replace metal, reduce original costs by 10%, eliminate corrosion problems, speed assembly. Solved with INSUROK T-301-TR.



10 Plastic air cylinder cup follower saves 40% in costs, eliminates scratches on cylinder walls, weighs less. INSUROK T-640 replaced metal.

For complete details on any of the above examples, circle the number(s) and return this coupon.

1 2 3 4 5 6 7 8 9 10

THE RICHARDSON COMPANY

Dept. 16

2795 Lake Street, Melrose Park, Illinois.

Laminated Fabricated and Molded Plastics

Name _____

Position _____

Company _____

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YOU may be one of those engineers who enjoys the technical side of engineering but doesn't want to specialize too deeply in one subject area. If you also enjoy writing, and meeting people, you might consider the possible satisfactions of a career in engineering journalism.

Specifically, MACHINE DESIGN is strengthening its editorial staff and needs an assistant editor with electrical or mechanical engineering education and experience. A recent EE or ME degree and about three years in development, design, or related work would be ideal background for this job.

Our staff consists of three major groups which work respectively on the technical contributed articles, on the news features and stories, and on the quarterly "Books" program. A basic requirement for all three activities is ability to write, rewrite, or edit copy for clarity and fast communication.

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We live and work in Cleveland, Ohio, and travel when necessary to interview authors, to attend meetings and expositions, etc. Our company, the Penton Publishing Co., employs over 600 people, about 60 of whom are editors, and publishes five magazines in the technical and business fields. Because our editors must be engineers, salaries are comparable to those in industry for equivalent experience and performance.

If this idea appeals to you as a career opportunity rather than just another job, why don't you write to me at the address on Page 4, outlining your education, experience, and interests, and enclosing a sample or two of your writing?

Colin Carmichael

EDITOR

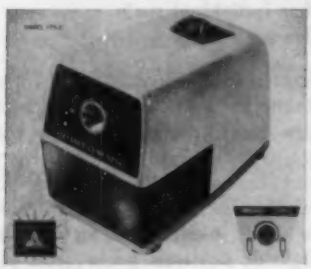
ENGINEERING
DEPARTMENT

EQUIPMENT

Electric Pencil Sharpener

permits dialing of point width desired

Point-O-Matic electric pencil sharpener contains an automatic indicator which lights up when pencil is sharpened, and a dial for choice of point width. Large visual receptacle is easily removed. Motor is sealed



in so that it will not become clogged by scraps. Unit operates on 115 v ac, 50 w. It measures 3⅝ x 6½ x 5¼ in. **Matsushita Electric Co. of America**, 41 E. 42nd St., New York 17, N. Y.

Circle 682 on Page 19

Laboratory Feed Pump

has maximum capacity of 2½ gph

Micro-Regulating laboratory feed pump incorporates a hydraulically actuated diaphragm design which provides zero-leakage pumping. Fluids are not contaminated by packings or seals, and are contained by a metal-to-metal diaphragm seal. Pump is available for maximum pumping capacity of 2½ gph. Six different plunger sizes, three standard gear ratios, and three motor speeds are available. Type 316 stainless steel is used for all wetted parts to provide maximum corrosion resistance. Explosionproof motors are standard equipment. Micrometer adjustment of stroke length utilizes ten full turns of the adjustment knob from zero to maximum flow for precise control of pumping

We call the metal parts shown here Ultra-Special because they are the result of completely new cold-forming and finishing techniques. They are typical examples of how users are reducing costs by taking advantage of the strength, improved quality, close dimensions and economy of mass-producing parts by cold-forming.

In the past, the limitations of the cold-forming process forced manufacturers to accept parts which were made by other, more costly methods. Now, through extensive research and development work Townsend is cold-forming Ultra-Special items with intricate shapes and critical dimensions held to tolerances as close as .001 inch. They may be made by combining cold-heading processes with impact extrusions, special heat-treatment and coatings, to name but one of the new techniques.

The use of Townsend Ultra-Special items in your product assembly could provide the means to make better products at lower costs. Investigate by asking a Townsend field engineer to call. Write Townsend Company, Engineered Fasteners Division, P. O. Box 71-E, Ellwood City, Pa.

A textron COMPANY

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ESTABLISHED 1816

Engineered Fasteners Division

ELLWOOD CITY • PENNSYLVANIA

In Canada: Parmenter-Bulloch Manufacturing Co., Limited, Gananoque, Ontario

Circle 357 on Page 19

for −100° F to 500° F applications

Select the right Temp-R-Tape for your job from a variety of types which combine some form of Teflon, Fiberglas or Silicone Rubber backing with a silicone polymer adhesive. Temp-R-Tapes possess high dielectric strength, thermal stability, excellent moisture resistance, non-aging characteristics and many other desirable properties.

CLASS H INSULATION USES: slot lining; interlayer and interphase insulation; harness bundling; splicing; wrapping for microwave components, transformer coils, capacitors and high voltage cables.

NON-STICK USES: non-stick facings for film guides in electronic instruments, heat sealing bars, forming dies, chutes, guide rails, etc.

AVAILABLE FROM STOCK: 1/4" to 2" widths, 18 yd. and 36 yd. rolls and 12" width on liner by lineal yard. Sold through distributors.

FREE SAMPLE and folder — write, phone or use inquiry service.

ELECTRICAL AND INDUSTRIAL SPECIALTY TAPES

CHR CONNECTICUT HARD RUBBER CO.

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Main office: New Haven 9, Connecticut

Circle 359 on Page 19

Design Guide to

Adjustable-Speed Drives

- ELECTRICAL
- MECHANICAL
- HYDRAULIC

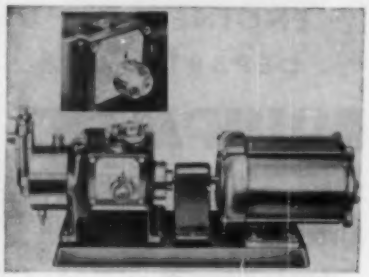
$2.00 per copy

Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

(Remittance or Company Purchase Order must be enclosed with order.)

MACHINE DESIGN READER SERVICE

Penton Building
Cleveland 13, Ohio



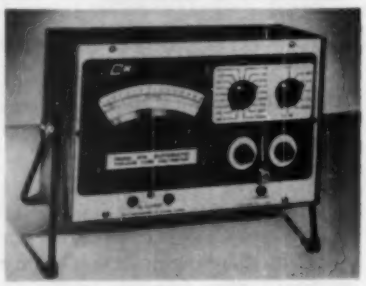
rate. Adjustments can be made while pump is operating or idle. **Whitey Research Tool Co.**, 5525 Marshall St., Oakland 8, Calif.

Circle 683 on Page 19

Vacuum-Tube Voltmeter

has individual scale for each range

Direct-reading Dynamatic 375 automatic vacuum-tube voltmeter provides quick, direct, error-free readings without multiplying. Instrument has an individual wide-view scale for each range, and all scales are direct reading. Unit utilizes a single dc-ac ohms probe, and anti-parallax mirror. Swivel stand permits tilting the instrument to any desired viewing angle, or swings up as a carrying handle. Accuracy is 3 per cent full scale ac and dc.



Unit operates on 117 v 50-60 cycle ac. **B & K Mfg. Co.**, 1801 W. Belle Plaine Ave., Chicago 13, Ill.

Circle 684 on Page 19

Photocopy Machine

makes black-and-white copies from any color

New 15-in. ElectraMatic photocopy machine has an extra-wide throat which accommodates large engineering documents or any large-size original. Machine provides bright, sharp, black-and-white photographic

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER GUIDANCE— VITAL FACTOR IN BEARING LIFE

Roller guidance has been established by the Anti-Friction Bearing Manufacturers Association as a major rating factor for roller bearings. There is a direct relationship between this factor and the life and capacity of a cylindrical roller bearing under load.

Figure 1 illustrates the results of a loose fit between a roller and the guiding ribs of the raceway. Because of lack of guidance by the ribs, the roller is free to skew and skid under load. Such a condition invariably leads to early bearing failure.

To achieve close roller fit and proper roller guidance, Bower precision grinds each bearing race on specially designed centerless grinders. In this operation, Bower positions the integral raceway ribs *from the theoretical centerline of the bearing*. This method produces bearings with high dimensional accuracy and perfect symmetry.

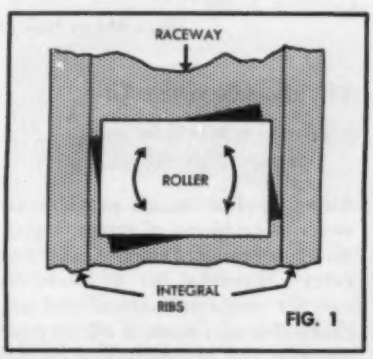
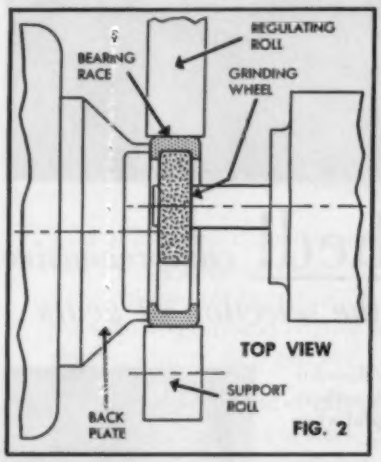
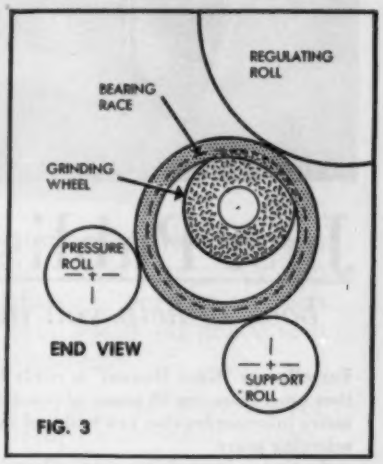


Fig. 1. Loose fit in raceway means poor roller guidance. Roller can skew and skid under load.

In addition, the close tolerances held in grinding the roller track and integral guiding ribs give Bower cylindrical roller bearings the ability to *take thrust in any direction*. A Bower cylindrical roller bearing has thrust capacity of from 10-15% of its rated radial capacity!



Figures 2 and 3 diagram the centerless grinding method used to finish Bower raceways. Use of this technique assures not only optimum roller guidance and maximum bearing life, but also virtually eliminates bearing runout. BEARING SYMMETRY WHICH RESULTS FROM THIS TECHNIQUE PERMITS ACCURATE SHAFT LOCATION REGARDLESS OF HOW THE OUTER RACE AND ROLLER ASSEMBLY ARE INSTALLED. IT COMPLETELY ELIMINATES THE POSSIBILITY OF IMPROPER INSTALLATION.



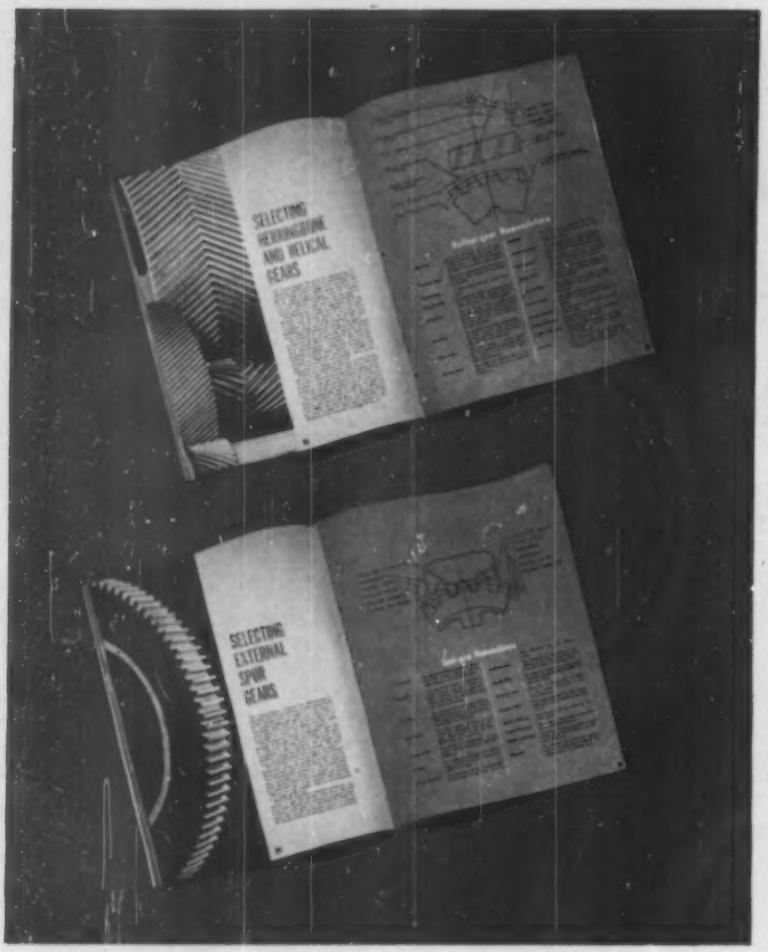
★ ★ ★ ★

Whatever your bearing needs, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

Circle 360 on Page 19



Just Published! *comprehensive book to help you in the selection of gears*

Farrel's new "Gear Manual" is ready for distribution now. Here are 68 pages of practical, authoritative information that you will find helpful when selecting gears.

Sections devoted to gear selection include: nomenclature, formulas for determining dimensions, procedure for calculating horsepower ratings and sample calculations. Gears for special use, such as in rolling mills and kilns and for pump rotors, are covered. Also discussed: lubrication, gear-tooth wear and failure and use of the gear-tooth comparator.

The manual is informative yet easy to use. Where possible, formulas have been simplified to reduce the calculations required.

Write for a copy today on your company letterhead.

FB-1227

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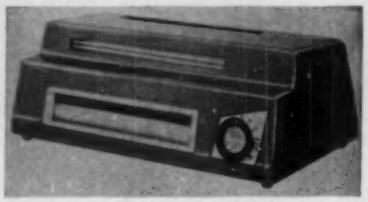


copies from any color in ordinary room light. Fluid is sealed in a disposable plastic cartridge that can be replaced quickly. **Photorapid Corp.**, 142 Oregon St., El Segundo, Calif.

Circle 685 on Page 19

Humidity Meter

has ±2 per cent accuracy

Transistorized humidity meter, Humistat, has a highly sensitive element incorporated as a probe. Probe is inserted through a port (shown) and gives instantaneous relative humidity readings with a ±2 per cent accuracy. Sensing element in the probe is a semiconductor whose electrical resistance changes instantly with changes in relative humidity. Unit can also be utilized as a permanently wired-in instrument for continuous monitoring and readout,

or it can be incorporated in other products as an OEM component. **Telostat Corp.**, 1003 First St. S., Hopkins, Minn.

Circle 686 on Page 19

Vibration-Damping Kit

permits selection of over 15 damping effects

Airpot application kit provides answers to problems of system stabilization, vibration damping, and time delay. Intended as a laboratory tool for electromechanical and mechanical-design work, it allows rapid selection and observation of over 15 different damping effects. Applica-

Circle 361 on Page 19

tions booklet included in the kit contains full instructions. Three Airpots form the basis of the kit and offer a choice of damping modes. Each unit is constructed of a low-expansion glass cylinder, precision-fitted with a carbon piston to toler-

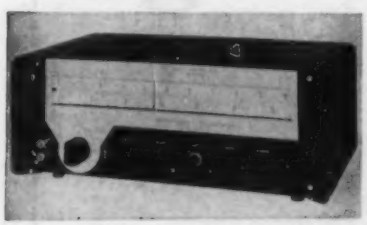
ances closer than 0.0002 in. A color code assures that the correct piston is inserted into its matching cylinder. After the damping mode is selected, there is a choice of five different coupling springs to link damping action to the device or system. Screwdriver adjustment allows the unit to be set for any amount of damping action. **Electric Regulator Corp.**, Pearl Street, Norwalk, Conn.

Circle 687 on Page 19

Servo Voltmeter

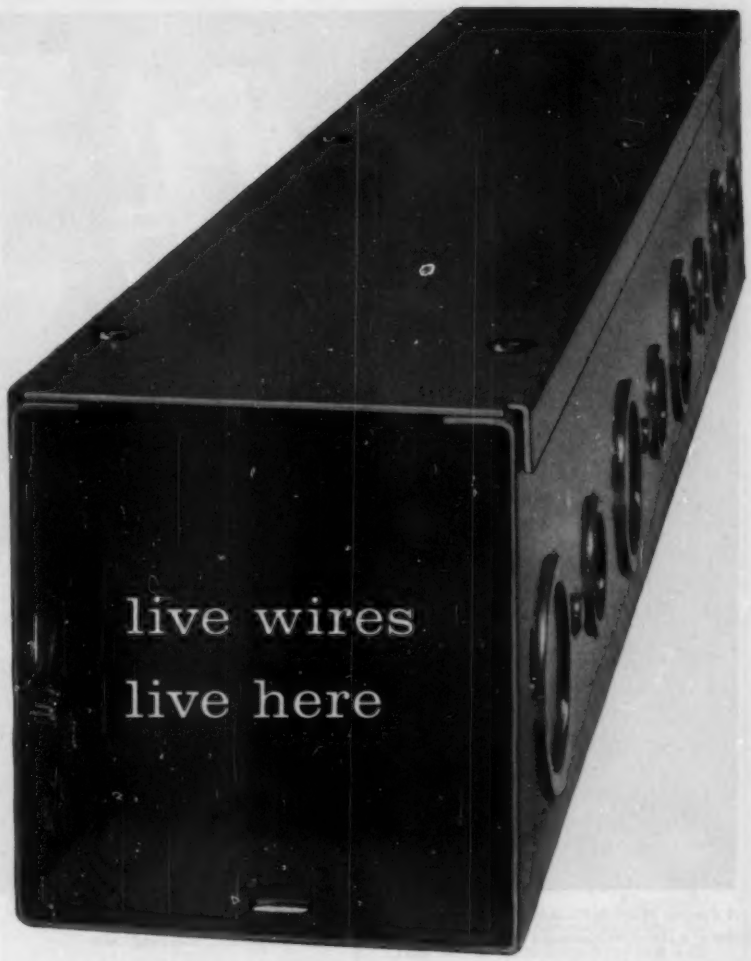
provides true potentiometric measurement of dc voltages

Model HV-160 dc servo voltmeter provides high input impedance on all scales. Input is potentiometric (over 100 megohms) on ranges from 3 mv to 1 v, and is 10 megoms on ranges from 3 to 300 v. Servo gain is automatically adjusted for each scale by the range switch. Accuracy is 0.15 per cent on eleven selectable scales. Indication is provided by knife-edge pointer on 14-in. mirror



scale. Hardware is provided for rapid conversion from case to rack mounting or vice-versa. **Houston Instrument Corp.**, P. O. Box 22234, Houston 27, Tex.

Circle 688 on Page 19



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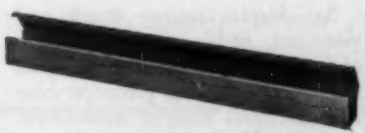

Wireways and Auxiliary Fittings

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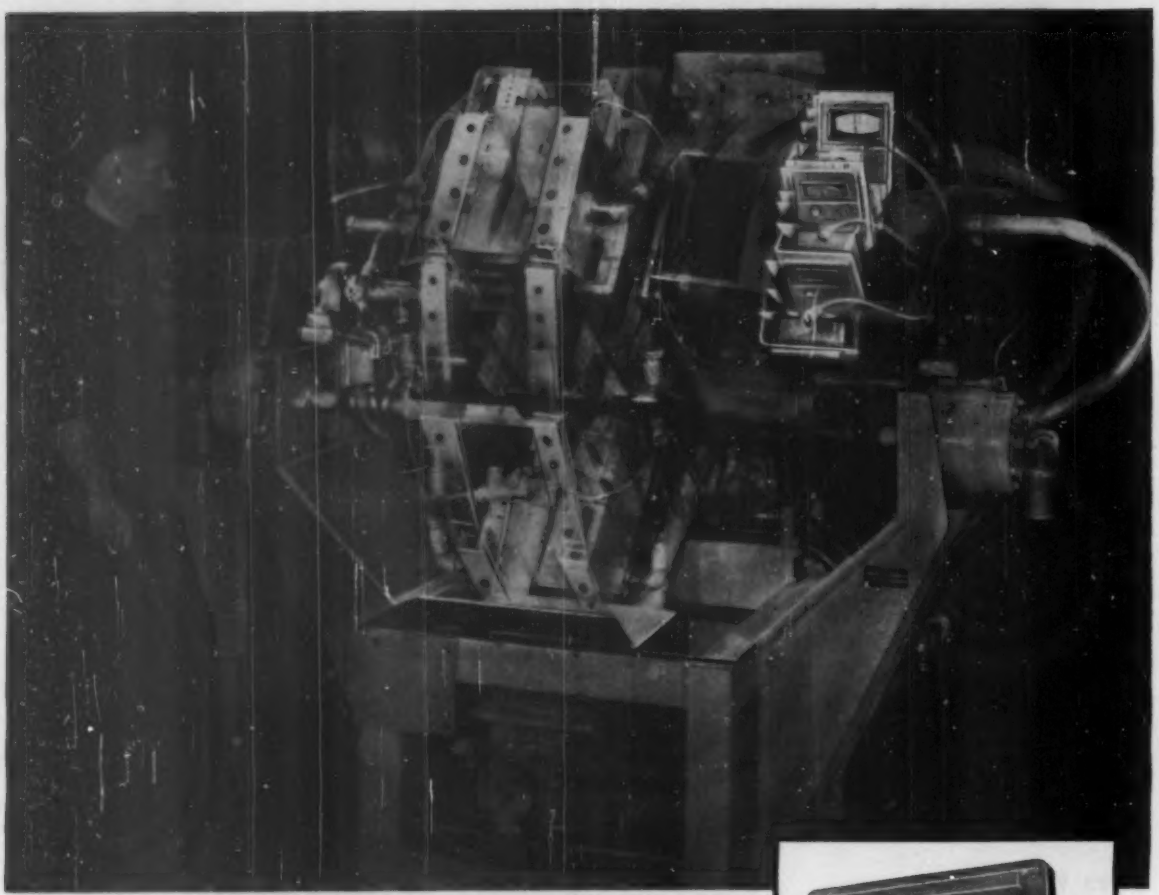
Circle 362 on Page 19



A Partlow Model MFS indicating controller is shown in action in this "multiple exposure" shot of a Hole-Core Automatic Molding Machine manufactured by Spo, Inc., Cleveland, Ohio.

The Temperature Control Built to
SHRUG OFF SHOCK
2438 Times a Day

Every working day, the Partlow Temperature Control in this photo takes between 2400 and 2500 solid "roundhouse punches" from the shell-molding machine to which it is attached.

But despite jarring shock and vibration, and a constant barrage of foundry dust, the Partlow goes right on delivering precision control—without letup or breakdown.

Actually, only a control as simple and rock-solid as the Partlow could withstand this kind of punishment! Because only the Partlow contains no hairsprings, or delicate gadgets.

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If you use or manufacture equipment within this temperature range, there's a Partlow to fit your application exactly . . . and save you money, too. Available in Pneumatic, Electric or Self-Contained Gas types, in recording, indicating or non-indicating models! To field test any Partlow control . . . or to obtain full details write, The Partlow Corporation, New Hartford, N. Y. Dept. D-1061.

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A complete absence of gadgets and superfluous parts, as seen in this open view of the new MFS indicating control, explains the Partlow's unique ability to function accurately even under the most severe operating conditions.

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Recent Books

Electromechanical Components for Servomechanisms. *By Sidney A. Davis and Byron K. Ledgerwood; 338 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$11.50 postpaid.*

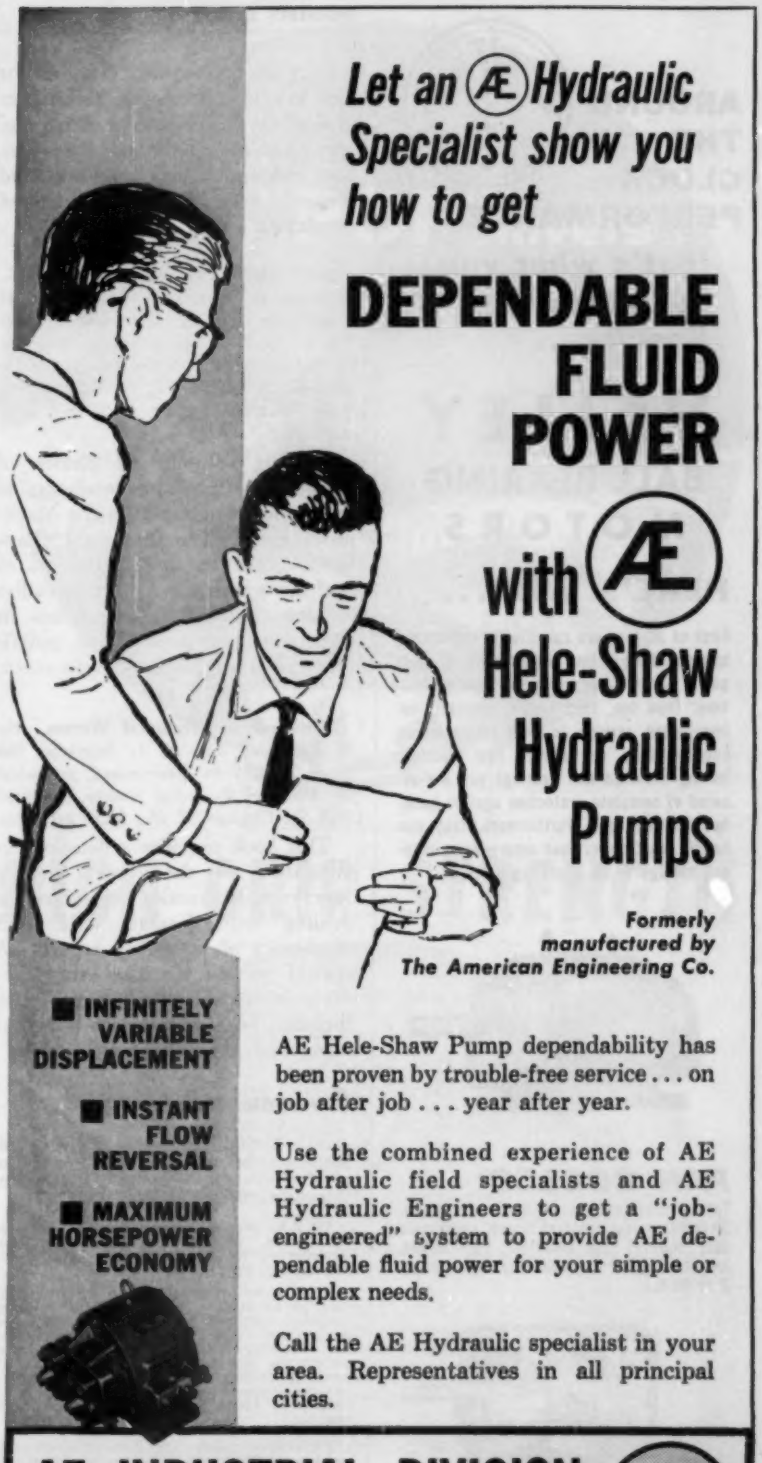
This volume presents facts and data for use in selecting and applying rotating components in the design of precision servomechanisms. It shows what to look for in buying components and how to specify them for maximum reliability. Design features of the various components—materials, winding distribution, skew—are analyzed to show how they affect the components' performance in a system. Examples illustrate how equivalent circuits can be used to determine shifts in component characteristics caused by changes in temperature, frequency, line voltage and capacitance, etc.

Mathematical Methods for Scientists and Engineers. *By Lloyd P. Smith; 453 pages, 5½ by 8½ in., paperbound; published by Dover Publications Inc., 180 Varick St., New York 14, N. Y.; $2.00 per copy.*

This book covers mathematical methods and information widely used in solving engineering and physics problems. The author includes illustrative problems typical of those which appear in physical and engineering literature. Practice problems are also presented at the end of each chapter. Many of these are taken directly from scientific literature and represent problems encountered in actual practice.

Operational Electricity. *By Charles I. Hubert; 530 pages, 5¾ by 9 in., clothbound; published by John Wiley & Sons Inc., New York, N. Y.; available from* MACHINE DESIGN, *$8.50 postpaid.*

This book presents an integrated study of ac and dc circuits and machines. The book stresses the fact that fundamental laws apply to both systems—that dc is only a special case of ac at a frequency of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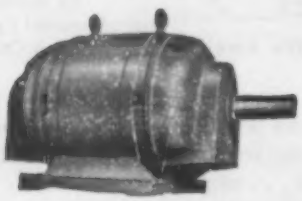

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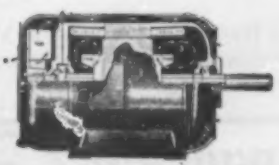

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Circle 365 on Page 19

zero cycles per second. The author has injected operating techniques in addition to treatments of parallel operation of generators, the selection and application of motors and controls, magnetic controllers, and regulators.

Sheet Metal Drafting. *By Melvin L. Betterley, Professor and Head, Dept. of Engineering Drawing, University of Iowa; 7¼ in. by 10 in., paperbound, published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$6.50 per copy postpaid.*

In this volume, all phases of drawing are integrated and applied to various situations in the sheet-metal field. The first eight chapters concern the basic elements of drafting which serve as preparation for the sheet-metal applications in the chapters on parallel-line, radial-line and triangulation development.

Handbook for Technical Writers. *By R. C. Tracy and H. L. Jennings; 134 pages, 7 by 10 in., paperbound; published by American Technical Society, 848 East 58th St., Chicago 37, Ill.; $3.50 per copy.*

This book provides a detailed examination of the report writing function. Instructions are given for dealing with format, style, and mechanics of preparing reports. A special section discusses the handling of classified material. Also included is a glossary of technical terms and abbreviations.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

TT F-65. Model Experiments on Atomization of Liquids. By Mintscho Popov. Technical Translation, NASA; 33 pages, 8 by 10½ in., paperbound, stapled; $1.00 per copy.

This paper discusses the similarity laws for the atomization of liquids with constant material properties and to verify them by comparison model experiments. The derived and experimentally verified similarity laws permit the modeling of the atomization processes of liquids whereby considerable simplifications in experimental procedure and generalization of the experimental data are made possible.

PB 161235. Summary of Present Information on Impact Sensitivity on Titanium when Exposed to Various Oxidizers. By W. K. Boyd, Asst. Chief, Corrosion Research Div., Battelle Memorial Institute; 7 pages, 8 by 10½ in., paperbound, stapled.

Experimental evidence indicates that, under certain conditions of impact, titanium and its alloys may ignite in strong oxidizers. However, only in the case of LOX (liquid oxygen) does there appear to be danger that the reaction will propagate and completely consume the titanium. In most cases, even though ignition occurs, the damage is not significantly greater than that occurring as a result of impact alone.

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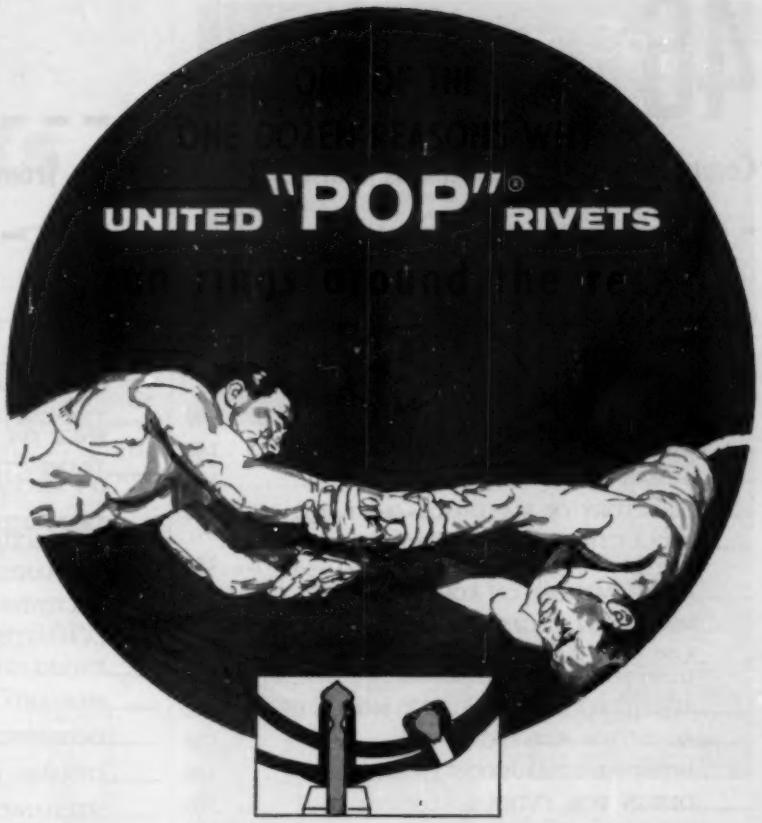

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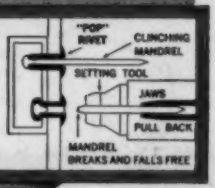

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Patents

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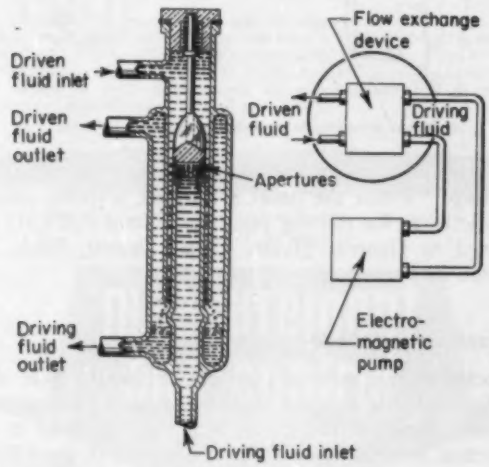

through the passage, it drags the driven fluid along. This action produces a transfer of energy between the fluids creating a pressure on the driven fluid. At the bottom of the passage, the mixed fluids pass over an enlarged section and are separated because of the differences in specific gravities. The lighter driven fluid then passes out through an upper port, while the heavier driving fluid leaves through a lower port to be recirculated by the electromagnetic pump. *Patent 2,978,985 assigned to Radio Corp. of America, Delaware, by Nils E. Lindenblad.*

Variable-Ratio Lever Mechanism

Pedal-operated lever shifts automatically from one pivot point to another during operation to change mechanical advantage of the system. Mounted between two support brackets, the lever carrys upper and lower pivot rollers which alternately engage mating slotted seats in the support brackets as the lever is rotated. In the starting position (left), the lower pivot roller is engaged with its seat, permitting maximum lever move-

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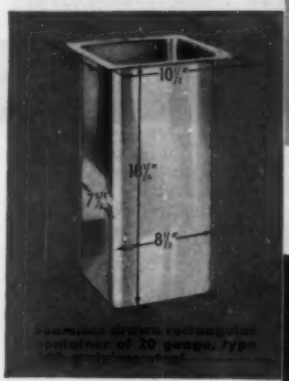

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Illustration above is unretouched photograph of actual stator cross-section showing extremely compact construction of EMD CLOSED-BORE design.

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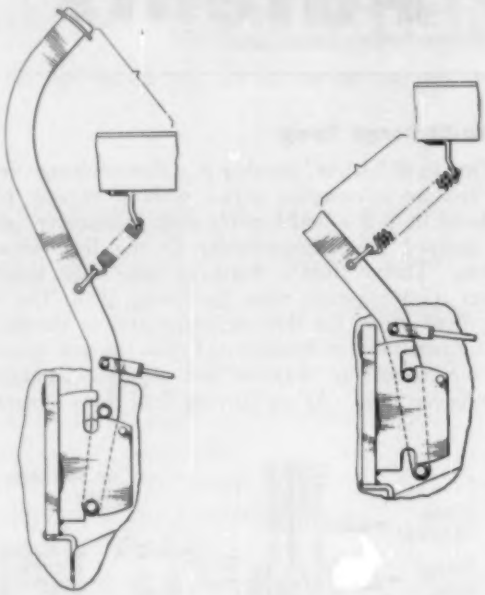
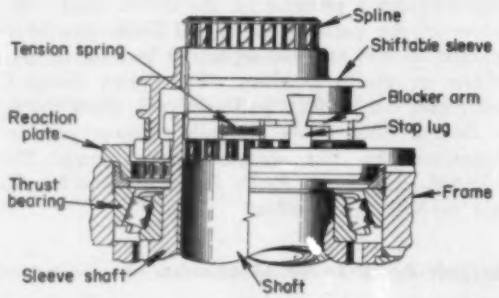
ment to take up slack in the linkage system. After the lever has been rotated through a prescribed angle, the upper pivot roller drops into its seat, reducing the



effective pivot radius and increasing the mechanical advantage. When the pedal is released, a spring returns the lever to the starting position. *Patent 2,977,817 assigned to General Motors Corp., Detroit, Mich., by Anton Z. Panasewicz.*

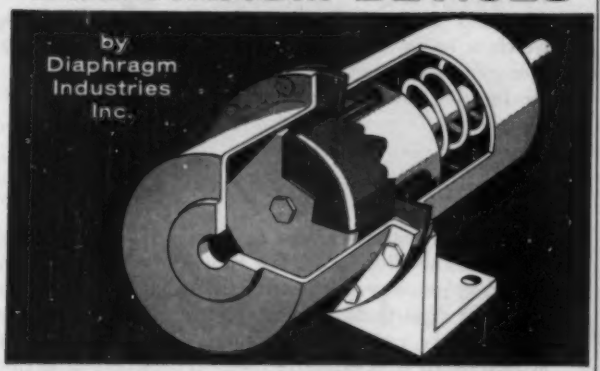
Synchronized Shift

Blocker device permits a reverse or locking gear shift only when the rotating shaft has slowed down to zero speed. Heart of the device is a stop lug fixed to the reaction plate and operating in a groove in the blocker arm which is attached to a friction band surrounding the shiftable sleeve. In initial position, the shiftable sleeve, splined to the shaft, is connected to the sleeve



shaft by internal teeth on the shiftable sleeve, and external teeth on the sleeve shaft. The stop lug is stationary, so blocker arm and band are stationary, sliding on the shiftable sleeve, which rotates. When the shiftable sleeve is moved to neutral (shown), the blocker arm "hangs up" on one of the shoulders of the stop lug, so that the shift cannot be completed. However, when the

DIAPHRAGMS AND DIAPHRAGM DEVICES



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Complete diaphragm assemblies such as actuators, positioners, accumulators and other diaphragm-operated devices are available now in prototype or production quantities.

The rolling diaphragm actuator shown above features:
FRICTION-LESS ACTION • ELIMINATION OF BREAKOUT FRICTION EFFECTS CONSTANT EFFECTIVE PRESSURE AREA • A LEAKPROOF MECHANISM EXTREME SENSITIVITY TO PRESSURE DIFFERENTIALS

Each elastomer-fabric diaphragm is engineered to fulfill your most stringent specifications: temperatures from −65°F to +550°F; pressures from 1" H_2O to over 500 psi; and compatibility with most gases and fluids.

We welcome the opportunity to quote. Forward complete specifications and details of your requirements for either diaphragms or complete diaphragm assemblies.

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Circle 371 on Page 19

measurement and control

OF PRESSURE AND DIFFERENTIAL PRESSURE

DELTADYNE® SWITCHES
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Adjustable for signalling pressure and differential pressure from 0.25" wc to 200 psi (or psid) in systems to 5000 psi and −65° to +275°F; leak-proof. Units sound alarm, light bulb, turn motor on or off, operate valves—remotely or in place. **$40 to $75**

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For system pressures to 3000 psi; indication from 0 to 60 psi differential; leak-proof—no moving seals; high-visibility scale. **$82**

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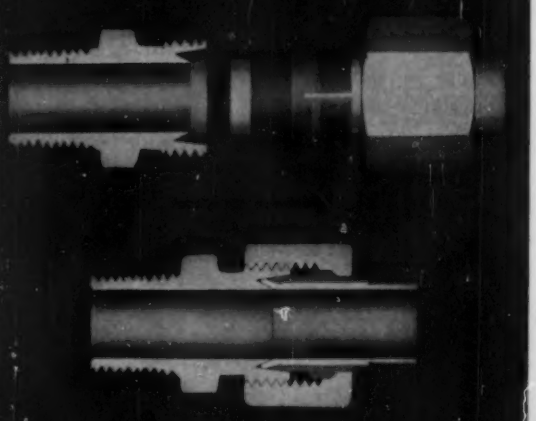

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Self-Flare Tube Fittings

The Efficiency Of A Flare Fitting — Can be used on thin wall tubing — provides a seal on the ID of the tube.

The Easy Installation Of A No-Flare Fitting — no time consuming flaring operation — no flaring tools required. Can be used with heavy-wall tubing and, provides a seal on the OD of the tube.

- Easy Assembly — Simply insert tube into fitting and tighten nut. "Rock Bottom" stop and signals that joint is sealed.
- Double Seal — seals on both outside and inside of the tube.
- Lower Cost — FLODAR'S Self-Flare fittings cost less to buy and install.

Tube shearing and work hardening are eliminated . . . FLODAR Self-Flaring fittings can be reassembled time after time without fear of leakage or damage to tube and fitting.

Priced competitively, this fitting is available in tube sizes from ⅛" to 2" and in steel, stainless, brass and aluminum.

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- Flare & No-Flare-Type Fittings
- High Pressure Pipe Fittings
- Straight Thread Tube Fittings
- Metal-to-Metal Porthole Fittings
- "O"-ring Type Porthole Fittings

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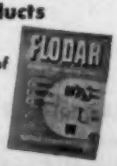

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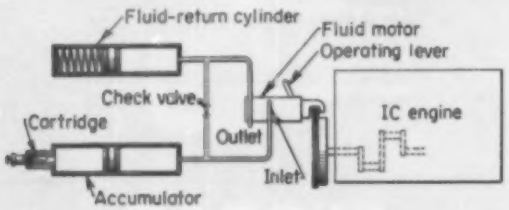
Circle 373 on Page 19

shaft has decelerated to zero speed, and commences reverse rotation, the blocker arm moves off the stop-lug shoulder. The shift can then be completed, connecting external gears on the shiftable spline to internal gears on the reaction plate. *Patent 2,990,044 assigned to Eaton Mfg. Co., Cleveland, Ohio, by Robert C. Russell.*

IC Engine Starter

Explosive cartridge provides pressure boost to drive fluid motor in a closed hydraulic circuit for an internal-combustion engine starting system. When the cartridge is fired, the expanding gases act on an accumulator piston to pressurize the input hydraulic line



to a fluid motor. The fluid motor is connected to the engine crankshaft through a reduction gear arrangement and provides a fast cranking action for starting. When the motor pinion is disengaged from the engine gear by a manually operated lever, the hydraulic fluid is discharged into a fluid-return cylinder with a spring-loaded piston. Removal of the firing mechanism for cartridge replacement opens one side of the accumulator piston to atmospheric pressure. The hydraulic fluid, which is under pressure in the fluid-return cylinder, is then returned through a check valve to the accumulator for the next starting operation. *Patent 2,981,056 assigned to International Harvester Co., Chicago, Ill., by Adna R. Clark and George E. Coleman.*

Ring gear for attachment to differential-gear housing uses shallow-recesses on the inner bore, rather than drilled holes, to permit fastener assembly. The recesses minimize distortion during heat treatment of the gear and simplify assembly operations. Final assembly is accomplished with explosive rivets to overcome problems of limited clearance and misalignment. *Patent 2,978,921 assigned to The Gleason Works, Rochester, N. Y., by Martin A. Donohoe.*

Self-regulating hydraulic system maintains constant fluid flow from a variable-volume pump. A differential-pressure condition is produced in the output line by an orifice. Changes in flow alter the pressure ratio and are sensed by a differential-pressure valve. This valve actuates a piston which positions the control ring of the variable-volume vane pump to regulate output flow. *Patent 2,975,717 assigned to Racine Hydraulics & Machinery Inc., Wisconsin, by Robert D. Rynders and Edward O. Brannon.*

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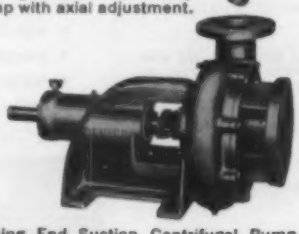

Deming End Suction Centrifugal Pump with semi open impeller, for outstanding performance and wear resistance.

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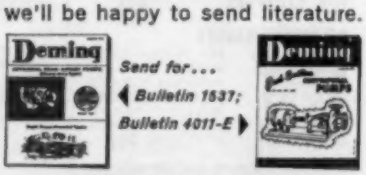

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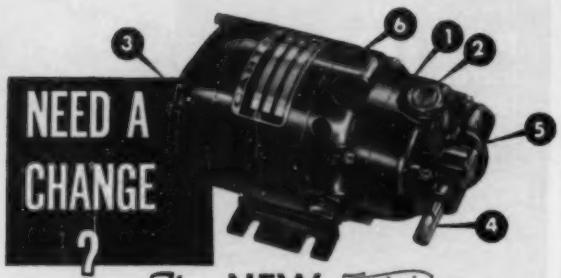

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Carter Classic Gearmotors give you the mass production economies of "standard" models, yet can be custom-modified to meet your needs without the penalizing cost of a "special" job. Interchangeable with most competitive types, too. Quality built for top performance. 50 catalog models. Hundreds of variations promptly available. Series motors 6 to 220 v., DC shunt motors 6 to 115 v. Classic motors, less gear reduction, available in 1/40 to 1/7 hp.

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Carter Motor

Carter Motor Company
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Large enough to Serve You — Small enough to Want to.

Circle 375 on Page 19

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35° and 45° Deep Trough Carriers

Pneumatic "Impact" Carriers

ADVANTAGES

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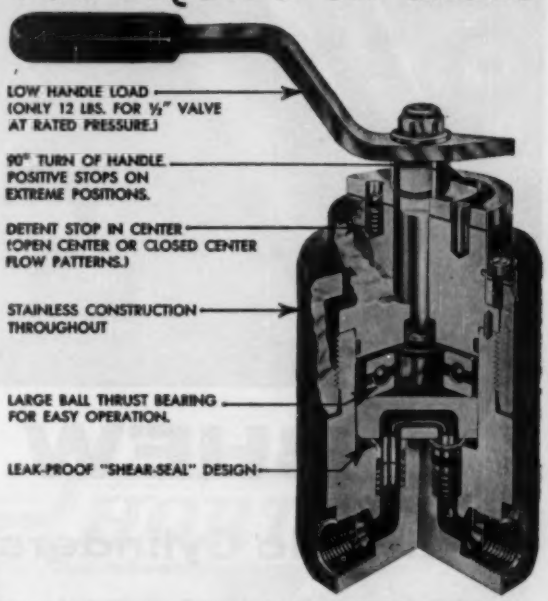
Circle 376 on Page 19

10,000 P.S.I.

4 WAY VALVE

FOR LIQUIDS OR GASES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STAINLESS CONSTRUCTION THROUGHOUT
LARGE BALL THRUST BEARING FOR EASY OPERATION.
LEAK-PROOF "SHEAR-SEAL" DESIGN

This new four-way valve series comes in pipe sizes from ¼ to 1 inch, but may be obtained with tube, AND 10050, or any preferred special high pressure connection. It will withstand surges of up to 15,000 P.S.I. without damage to the valve's sealing qualities. It is designed for a burst pressure of 30,000 P.S.I.

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Of course, there is no external shaft leakage, because the pressure is confined to the flow passages.

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CONTROL VALVE DIVISION

Barksdale valves

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- Specific Adaptations
- Application Engineering

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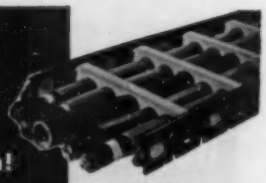

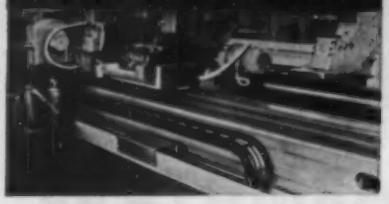

Write for suggestions on profitable POWERTRAK applications to your Equipment-in-motion

Your equipment will benefit with POWERTRAK—amazing invention for carrying power cable and hose on equipment in motion. Offers many advantages on machine tools, lathes, grinders, planers, presses, cranes and others. Protects power cables, oil, gas, and air hoses against wear from bending, crushing, abrasion, friction, pulling stresses and strains. Avoids machine downtime and cable or hose replacement expense.

POWERTRAK saves space, permits more flexibility in machine design. Handles multiple cable and hose up to 2½" diameter, up to 80 feet of travel, at moving speeds up to 160 feet per minute.

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TAKE-UP REEL HEADQUARTERS FOR ALL INDUSTRY

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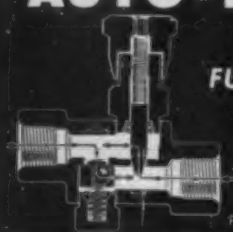
AUTO-PONENT®

HYDRAULIC FULL FLOW VALVES

Flow Control, Needle, Check, for HYDRAULIC Power



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A complete line: 1/8", 1/4", 3/8", 1/2", and 3/4" female Dryseal Pipe Sizes in all models and types. Equivalent Aeronautical Tube Sizes on special order.

MINIMUM PRESSURE DROP AND POWER LOSS . . . Oversize ports and passages give maximum flow at minimum pressure drop, insure greater accuracy and response in hydraulic or large volume air cylinder control.

EASY FLOW ADJUSTMENTS under full pressure. Seal located at port to eliminate air or dirt traps. Gland structure equally effective on pressure or vacuum.

SENSITIVE, CHATTERLESS BALL CHECK . . . Patented design insures rapid ball movement to open or close at low differentials.

FORGED BODIES permit higher pressures with wide safety margins. Aluminum—3000 psi; Steel and Stainless Steel—5,000 psi. Pressure ratings based on better than 5 to 1 safety factor. All internal parts are Stainless. Write for illustrated catalog.

Model F Standard Flow Control Valve or Model N Needle Valve

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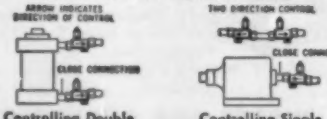
Model FF Knob and Dial Flow Control Valve or Model FN Needle Valve for panel mounting.

Model C Check Valve for In-Line Mounting.

TYPICAL APPLICATIONS



Controlling Double Acting Cylinder

Controlling Single Acting Cylinder

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Often the best way to get a message across is by demonstration. Our message is about mechanical shaft seals. We can give you plenty of facts about our seals—why they are better—why they are preferred by most manufacturers—why you should use them. Instead, we'd like to demonstrate the superiority of our seals by putting actual proof in your hands. Just give us your seal problem, we'll send a design proposal—then you decide. Write to: *Cartriseal Corporation, 3515 W. Touhy, Lincolnwood, Ill.*

CARTRISEAL

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HORTON

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STOP SURE! For stopping rotating parts! PANCAKE DESIGN takes less room—MOUNT ANYWHERE—torque arm or universal. 3 low-inertia models handle up to 4,300 inch lbs. torque. FORCED DRAFT COOLING dissipates heat fast; remote friction surface position guards against heat buildup and brake "fade." Control with static air pressure. Low cost! Ask about "Air-Champ" *clutches!* Write for brochure!

*Patent pending

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HORTON

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NEW

Series "A"

Heavy Duty
High Speed

INDEX TABLE

by CMC

The one unit that does bigger jobs better . . . Series "A" High Speed Index Table is quality to the highest standards . . . provids extreme accuracy of .001 on a 28" diameter . . . efficiently handles loads of 24,000 inch pounds, and over, with outstanding accuracy and maintains zero backlash in dwell position with a high-speed jerk-free operation . . . enables designers to make full use of modern high speed equipment.

With the New Series "A" Index Table You Get:

- Timken bearing near outside diameter of cam follower plate for greatly increased stability
- Supports dial plate load of 18,000 lbs.
- Machined housing surface for mounting tooling plate and permitting shaft mounted speed reducers to be fitted direct
- Immediate adaptability to dial plate of your choice
- Hollow output shaft enables air, fluids, coolants or additional tooling to be brought directly to center of work area
- Hardened, MACHINE GROUND tool steel cam; precision bearings; MACHINE GROUND critical components

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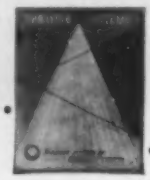
perhaps one of our **DATA SHEETS** *can suggest a solution*

For almost every spraying application, there's a Spraying Systems Data Sheet that gives useful information on suggested installations and types of nozzles to use. If you have a problem, write and let us know the application involved . . . and we'll send the Data Sheet that applies.



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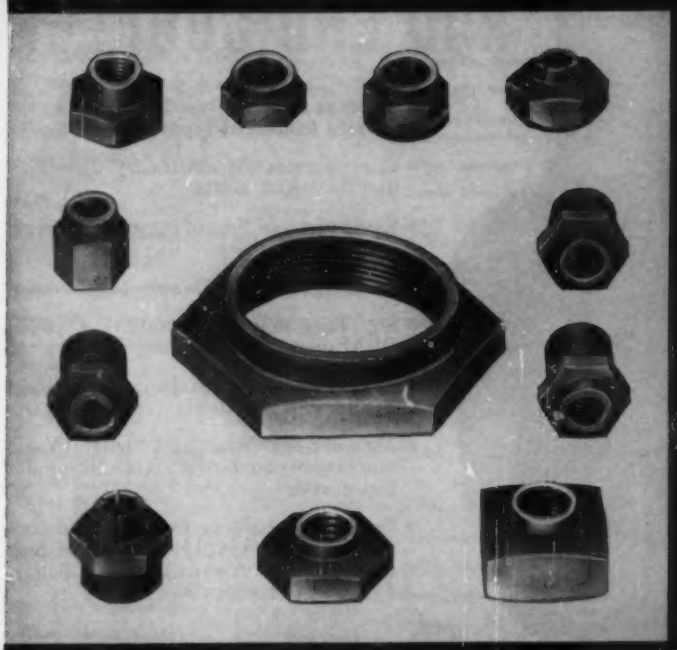
Circle 386 on Page 19

SPECIAL LOCKNUTS . . . *that solved fastening problems*



As the largest specialized nut manufacturer in the world we are constantly developing new methods and products for this phase of assembly in industry . . . in the field of locknuts we have made spectacular progress. Besides standardized hexagon "Conelok," "Huglock" and "Marsden," sizes #10—3" of ferrous and non-ferrous materials, we provide many special application nuts, upon a basis of these designs . . . a few of which are here shown . . . Our sales and engineering departments are available to help you solve your fastening problems . . . Send for 12-page condensus catalog, it includes complete specifications of our entire product, as well as engineering data. We also have an one hundred and forty four page catalog where more comprehensive information is required.

Manufacturers of Standard and Special ferrous and non-ferrous Hexagon, Square and "12 Pointer" nuts . . . "Conelok," "Huglock" and "Marsden" locknuts.

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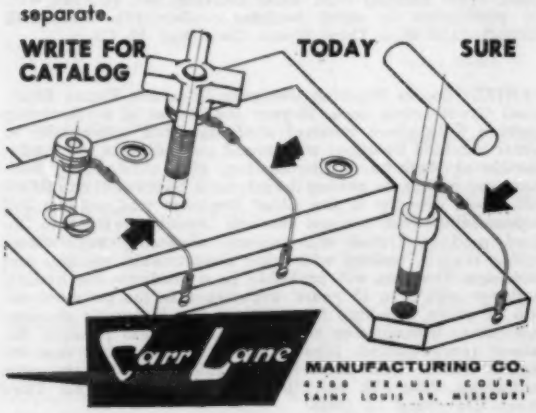
HORSE & BUGGY METHODS CAN COST YOU TIME & MONEY!

Use CARR-LANE'S Nylon covered cable instead of sash chain to attach jig components to fixtures.

Won't kink — stronger — less breakage nylon covered steel cable. Can be had as cable assemblies or just cable ferrules and rings separate.



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Looking for new solutions to heavy-duty power problems? This new brochure has full information on heavy-duty transmissions with input torque capacities of 150 to 2500 ft-lb. Included is "idea material" describing:

- Standard transmissions customized to each application
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- Specifications (capacities, speeds, gear ratios) for heavy-duty applications
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Send coupon for your free copy . . . or see our Catalog in *Sweet's Product Design File* today!

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Please send my copy of "Cotta Heavy-Duty Transmissions" to

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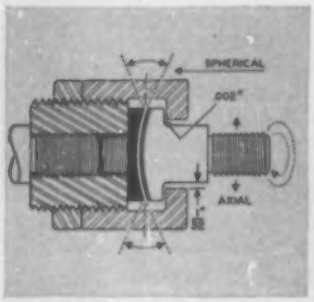
Spherical movement (on push only) and radial movement provide precision alignment between cylinder and machine. Couplers shipped with .002" clearance between floating head and shoulder of retaining nut.



- Reduces cylinder bearing wear caused by side loads and binding
- Compensates for machinery deflection due to weight shifts
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Circle 390 on Page 19

ENGINEERS AVAILABLE OR WANTED

AVAILABLE: Design Engineer for board work. Offering you competence, ability, and twenty years' experience on design of product, power press dies, automatic and other machinery, production tools; quality draftsmanship; ingenuity and originality on development of ideas. Temporary engagements or projects. Fee basis. Any location. Address: Boxholder, 202 Back Bay Postal Annex, Boston, Massachusetts.

WANTED: B.S.M.E. Five years experience. Challenging opportunity with an expanding Midwestern firm to handle the design of special machine tools and to oversee and develop new products. Starting salary $9,000. Send resume to Personnel Engineering, 1102 Broadway, Rockford, Illinois; 3300 Peterson Avenue, Chicago, Illinois. "Licensed and Bonded."

WANTED: Exceptional growth opportunity for design engineer of resistance and arc welders with adequately financed manufacturer starting diversification program. Must have extensive experience to carry through from complete design to supervision of production. Ideal Midwest location. Send complete resume. Box 104, MACHINE DESIGN, 1213 West Third Street, Cleveland 13, Ohio.

WANTED: Vibration Engineering. Today's leader in vibration/shock/noise control offers challenging opportunities to engineers: Design Engineers—B.S. in Engineering with general industrial experience. Knowledge of vibration engineering and/or rubber technology not mandatory. After initial training, function will involve design and analysis of complete shock and vibration control systems. Field Engineers—B.S. in Engineering with experience involving customer field engineering. Applications of junior design engineers with interest in field engineering and willing to undergo training will be considered. Eventual placement in field offices located throughout U. S. Send complete resume to: Employment Department, Lord Manufacturing Company, Erie, Pennsylvania.

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WANTED: Stress Engineer/Machine Designer. Machine Frame Structures. Great Lakes area 38-year old leader in earthmoving machinery field offers unusual challenge to Machine Designer to set up an Experimental Stress Activity. He will have strong interest and proven ability in experimental stress analysis and have had actual experience in the attachment and use of stress instrumentation, including interpretation of test data. The man will probably be a Graduate Mechanical Engineer with three to ten years' experience in the personal design of machine frame structures, gears, hydraulic circuitry and power transmission equipment. Permanent position. Excellent remuneration, liberal Profit Sharing Plan, other benefits. Sell yourself with full particulars in strict confidence. Box 101, MACHINE DESIGN, 1213 West Third Street, Cleveland 13, Ohio.

WANTED: Senior Machine Designer (Machine Frame Structures) Great Lakes area. 38-year old leader in earthmoving machine field offers unusual challenge and opportunity to Senior Machine Designer with sound grounding in the fundamentals of Mechanical Engineering, plus outstanding initiative and ability for getting the job done. Successful candidate will report directly to the Chief Engineer and assume full responsibility from concept through layout, stressing to finished product. Duties will include necessary supervision, writing reports, contact with other departments, vendors and field trips. The man will probably be a graduate Mechanical Engineer with 5 to 15 years' experience in the personal design of gears, machine frame structures, hydraulic circuitry and power transmission equipment. Permanent position. Excellent remuneration. Liberal profit sharing plan and incentive bonus. Sell yourself with full particulars in strict confidence. Box 100, MACHINE DESIGN, 1213 West Third Street, Cleveland 13, Ohio.

Advertising Index

ACF Electronics Division, ACF Industries 71
Acushnet Process Co. 187
AE Industrial Division of Aircraft Armaments, Inc. 233
Aeroquip Corporation 215
Alemite Division of Stewart-Warner Corporation 197
Allen-Bradley Co. 219
Allied Chemical Corporation, Plastics Division . 193
Allis, Louis, Co., The 52, 53
Aluminum Company of America 57, 58
American Brake Shoe Co., AmForge Division .. 206
American Brake Shoe Co., Denison Engineering Division 111
American Cast Iron Pipe Co., Acipco Steel Products Division 110
American Metal Climax, Inc., Climax Molybdenum Co. Division 29
American Smelting and Refining Co., Federated Metals Division 209
AmForge, A Division of American Brake Shoe Co. 206
Arwood Corporation 109
Atlas Chain & Manufacturing Co. 212
Automatic Switch Co. .....Inside Front Cover
Auto-Ponents, Inc. 242
Avis Industrial Corporation, Keystone Manufacturing Co. Division 231

Baldwin-Lima-Hamilton, Electronics & Instrumentation Division 174
Barksdale Valves, Control Valve Division 241
Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc. 100
Bendix Corporation, The, Bendix Products Division 43
Bendix Products Division, The Bendix Corporation 43
Benton Harbor Engineering Works, Inc. 242
Borg-Warner Corporation, Ingersoll Products Division 192
Borg-Warner, Rockford Clutch Division 2
Bower Roller Bearing Division, Federal-Mogul-Bower Bearings, Inc. 229
Bridgeport Brass Co., Cored Forgings Division 179
Briggs Filtration Co., The 190
Briggs & Stratton Corporation 16
Bruning, Charles, Co., Inc. 59

Cambridge Wire Cloth Co., The 86
Carpenter Steel Co., The 92
Carr Lane Manufacturing Co. 245
Carter Motor Co. 241
Cartrissal Corporation 243
Chain Belt Co. 27
Char-Lynn Co. 51
Chicago-Allis Mfg. Corporation 40
Climax Molybdenum Co., A Division of American Metal Climax, Inc. 29
Columbia-Geneva Steel Division, United States Steel Corporation 90
Commercial Cam & Machine Co. 244
Commercial Shearing & Stamping Co. 66
Connecticut Hard Rubber Co. 228
Controls Company of America, Appliance and Automotive Division 234
Cotta Transmission Co. 245
Cramer Division, Giannini Controls Corporation 189
Curtis Universal Joint Co., Inc. 234

Deming Division Crane Co. 240
Denison Engineering Division, American Brake Shoe Co. 111
Diamond Chain Co., Inc. 84
Diaphragm Industries, Inc. 239
Dings Brakes, Inc. 207
Doehler-Jarvis, Division of National Lead Co. 46
Dow Corning Corporation 191
Du Pont de Nemours, E. I., & Co., Inc. ..77, 78
Duralectallic Corporation 198
Durkee-Atwood Co. 217
Dymo Industries, Inc. 243
Dynamatic Division, Eaton Manufacturing Co. 93

Eastman Kodak Co., Graphic Reproduction Division 171
Eaton Manufacturing Co., Dynamatic Division 93
Electronics & Instrumentation Division, Baldwin-Lima-Hamilton 174
EMD Components, Inc. 238

Fairchild Engine & Airplane Corporation, Stratos Division 177
Farrel-Birmingham Co., Inc. 230
Fawick Airflex Division, Fawick Corporation .. 205
Fawick Corporation, Fawick Airflex Division .. 205
Federal-Mogul-Bower Bearings, Inc., Bearings Company of America Division 100
Federal-Mogul-Bower Bearings, Inc., Bower Roller Bearing Division 229
Federal Short Run Stamping, Inc. 244
Federal Stamping Co. 244
Federal Tool & Mfg. Co. 244
Federated Metals Division, American Smelting and Refining Co. 209
Flodar Corporation 239
Fumas Electric Co. 178

Gallad-Henning Mfg. Co., Napak Division .. 216
Gates Rubber Co., The 33
General Electric Co. 74, 94, 95
General Industries Co., The 37
General Time Corporation, Haydon Division .. 211
Giannini Controls Corporation, Cramer Division 189
Gits Bros. Mfg. Co. 85
Gleason Reel Corporation 242
Gleason Works 75
Graham Transmissions, Inc. 194
Grip Nut Co. 176

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Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio.

BPA NBP

backtalk—

—Vocabulary Explosion

We have been thanked by a reader for publishing an article which "enhances the language" of engineers in the field of dynamics ("Zing and Snap," by Daniel Stern, August 31, Page 112). With his thanks, Jack K. Willis, Staff Engineer, Ampex Corp., Redwood City, Calif., sent the following comments:

I would like to add another identity which has proven useful in the automotive industry as well as in some other areas of mechanism design for "white noise" environments. That is, to use the existing term in Detroit: JOUNCE. Jounce is the time-rate-change of jerk, or d^4s/dt^4, or dj/dt.

It is interesting to note the physical manifestations of space-time relationships as I learned them in Detroit while working on a project concerned with passenger riding comfort:

1. Displacement cannot be sensed.
2. Velocity cannot be sensed.
3. Acceleration imparts a sense of "push" to one's body.
4. Jerk sends ripples through one's flesh, and is annoying.
5. Jounce forcefully modulates these ripples and even penetrates to one's bones, imparting distinct discomfort. This is the parameter which breaks down passengers in tanks, trains, or armored weapons which are not adequately protected.

Mr. Stern replied to this by adding JOUNCE (as well as another word from his own vocabulary) to the table which appeared in his article. The same relationships hold true for rotational motion as in the original article.

It is fitting that Mr. Stern, who started the whole thing, gets in the last word: BOOM.

	Relationship	Units
Displacement	s	ft
Velocity	$v = \frac{ds}{dt}$	ft/sec
Acceleration	$a = \frac{dv}{dt}$	ft/sec^2
Jerk	$j = \frac{da}{dt}$	ft/sec^3
JOUNCE	$n = \frac{dj}{dt}$	ft/sec^4
Force or Torque	F	lb
Work	$W = Fs$	ft-lb
Power	$P = Fv$	ft-lb/sec
ZING	$Z = Fa$	ft-lb/sec^2
SNAP	$S = Fj$	ft-lb/sec^3
BOOM	$B = Fn$	ft-lb/sec^4

—And Words for the Wise

This business about words brings to mind the advance publicity on the Communications Conference of the National Office Management Association. W. T. Cavanaugh, Executive Director of NOMA, said, "Just to keep pace with the new words that come into our language, it would be necessary for each person to learn ten new words a week throughout his lifetime." Assuming that learning a new use for a word already in one's vocabulary counts as a new word, the preceding will give you a good start on this week's assignment.

—Physics and Felicity

Albert Einstein offered the following simplified and very graphic explanation of one of his theories: "When a man sits with a pretty girl for an hour, it seems like a minute. But let him sit on a hot stove for a minute—and it's longer than any hour. That's relativity."

—Brass Tacks

"Just about anyone associated with the use of copper, brass, or bronze" is invited to enter the 1962 Copper and Brass Achievement Awards Competition, the fourth such annual event sponsored by the Copper & Brass Research Association. Purpose of the awards is to honor outstanding new developments in the use or application of the copper metals in the U. S. Duplicate first prizes of $500 and bronze trophies will go to the best entries in Industrial and Architectural categories.

Industrial entries can be new or redesigned consumer products, original designs or concepts for established applications, production or manufacturing processes, marketing or promotion programs, or contributions to science and research that significantly involve use of the copper metals. Entry forms are available from the Copper & Brass Research Association, 420 Lexington Ave., New York 17, N. Y. Nominations must be received by March 31, 1962.

Advertising Index

Haydon Division of General Time Corporation 211
Haynes Stellite Co., Division of Union Carbide Corporation ... 70
Hitachi, Ltd. ... 96
Hitchiner Manufacturing Co. ... 196
Hole-Krome Screw Corporation, The ... 83
Horton Manufacturing Co., Inc. ... 243
Hunt Valve Co., Division of IBEC ... 41
Hydrodyne Industries, Inc. ... 196
Hydra-Line ... 246

IBEC, Hunt Valve Co. Division ... 41
Industrial Tectonics, Inc., Ball Division ... 42
Ingersoll Products Division of Borg-Warner Corporation ... 192

Jeffrey Manufacturing Co., The ... 250
Jones & Laughlin Steel Corporation, Stainless and Strip Division ... 97
Joy Manufacturing Co. ... 223

Knyden Engineering Corporation, The ... 21
Kennametal, Inc. ... 214
Keystone Manufacturing Co., Division of Avis Industrial Corporation ... 231
Keystone Steel & Wire Co. ... 117

LaSalle Steel Co. ... 7
Lewellen Manufacturing Co. ... 15
Linde Co., Division of Union Carbide Corporation ... 89
Link-Belt Co. ... 47
Lisle Corporation ... 175
Logansport Machine Co., Inc. ... 103
Lovejoy Flexible Coupling Co. ... 210
Lucas-Rotax Limited ... 56

McGill Manufacturing Co., Inc., Bearing Division ... 72

Mead Specialties Co., Mead Fluid Dynamics Division ... 1
Midland-Ross Corporation, Waldron-Hartig Division ... 218
Milford Rivet & Machine Co., The ... 224
Minnesota Mining and Manufacturing Co., Adhesives, Coatings and Sealers Division .. 69
Minnesota Mining & Manufacturing Co., Chemical Division ... 213
Minnesota Rubber ... 203
Morse Chain Co. ... 173, 175, 177, 179

National Acme Co., The ... 60
National Lead Co., Doehler-Jarvis Division .. 46
National Machine Products Co. ... 245
National Screw & Mfg. Co., The ... 112
National Tube Division, United States Steel Corporation ... 90
New Jersey Zinc Co., The ... 118
Nopak Division, Galland-Henning Mfg. Co. ... 216

Ohio Gear Co. ... 222
Oilgear Co., The ... 9
Olin Metals Division ... 11
Orange Roller Bearing Co., Inc. ... 195

Pall Corporation ... 239
Parker Fittings and Hose Division, Parker-Hannifin Corporation ... 36
Parker-Hannifin Corporation, Parker Fittings and Hose Division ... 36
Partlow Corporation, The ... 232
Peerless Electric Division, H. K. Porter Co., Inc. 116
Perkins Machine and Gear Co. ... 200
Pheoll Manufacturing Co., Inc. ... Inside Back Cover
Philadelphia Gear Corporation ... 44
Polar Ware Co. ... 237
Porter, H. K., Co., Inc., Peerless Electric Division ... 116
Porter, H. K., Co., Inc., Riverside-Alloy Metal Division ... 180, 181
Power Instruments, Inc. ... 190

Republic Steel Corporation ... 104, 105
Rhodes, M. H., Inc. ... 186
Richardson Co., The ... 225
Riverside-Alloy Metal Division, H. K. Porter Co., Inc. ... 180, 181
Robbins & Myers, Inc. ... 99
Rockford Clutch, Division of Borg-Warner .. 2
Rockwell-Standard Corporation, Universal Joint Division ... 102
Rohm & Haas ... 113
Roper Hydraulics, Inc. ... 182

Sealmaster Bearings, A Division of Stephens-Adamson Mfg. Co. ... 50
Sealol, Inc. ... 194
Sharon Steel Corporation ... 80, 81
Shell Oil Co. ... 115
Shenango Furnace Co., The, Centrifugal Casting Division ... 73
SKF Industries, Inc. ... 199
Spraying Systems Co. ... 244
Standard Products Division, Stephens-Adamson Mfg. Co. ... 241
Steel Founders Society of America ... 54, 55
Stephens-Adamson Mfg. Co., Sealmaster Bearings Division ... 50
Stephens-Adamson Mfg. Co., Standard Products Division ... 241
Stewart-Warner Corporation, Alemite Division 197
Stratos, A Division of Fairchild Engine & Airplane Corporation ... 177
Superior Carbon Products, Inc. ... 204
Superior Tube Co. ... 48, 49, 67, 68, 87, 88, 107, 108, 183, 184, 201, 202

Taylor Fibre Co. ... 220, 221
Technology Instrument Corporation ... 198
Tennessee Coal and Iron Division, United States Steel Corporation ... 90
Timken Roller Bearing Co., The ... Back Cover
Torrington Co., The ... 13
Townsend Co., Engineered Fasteners Division 227
Trent Tube Co. ... 114
Tubular Rivet & Stud Co. ... 5

Union Carbide Corporation, Haynes Stellite Co. Division ... 70
Union Carbide Corporation, Linde Co. Division ... 89
Union Carbide Corporation, Silicones Division. 45
Union Carbide Corporation, Union Carbide Plastics Co. Division ... 101
Union Carbide Plastics Co., Division of Union Carbide Corporation ... 101
United Shoe Machinery Corporation, Shelton Division ... 235
United States Steel Corporation, Subsidiaries ... 61, 62, 63, 64, 65, 90
United States Steel Export Co. ... 90
United States Steel Supply Division, United States Steel Corporation ... 90
Universal Joint Division, Rockwell-Standard Corporation ... 102

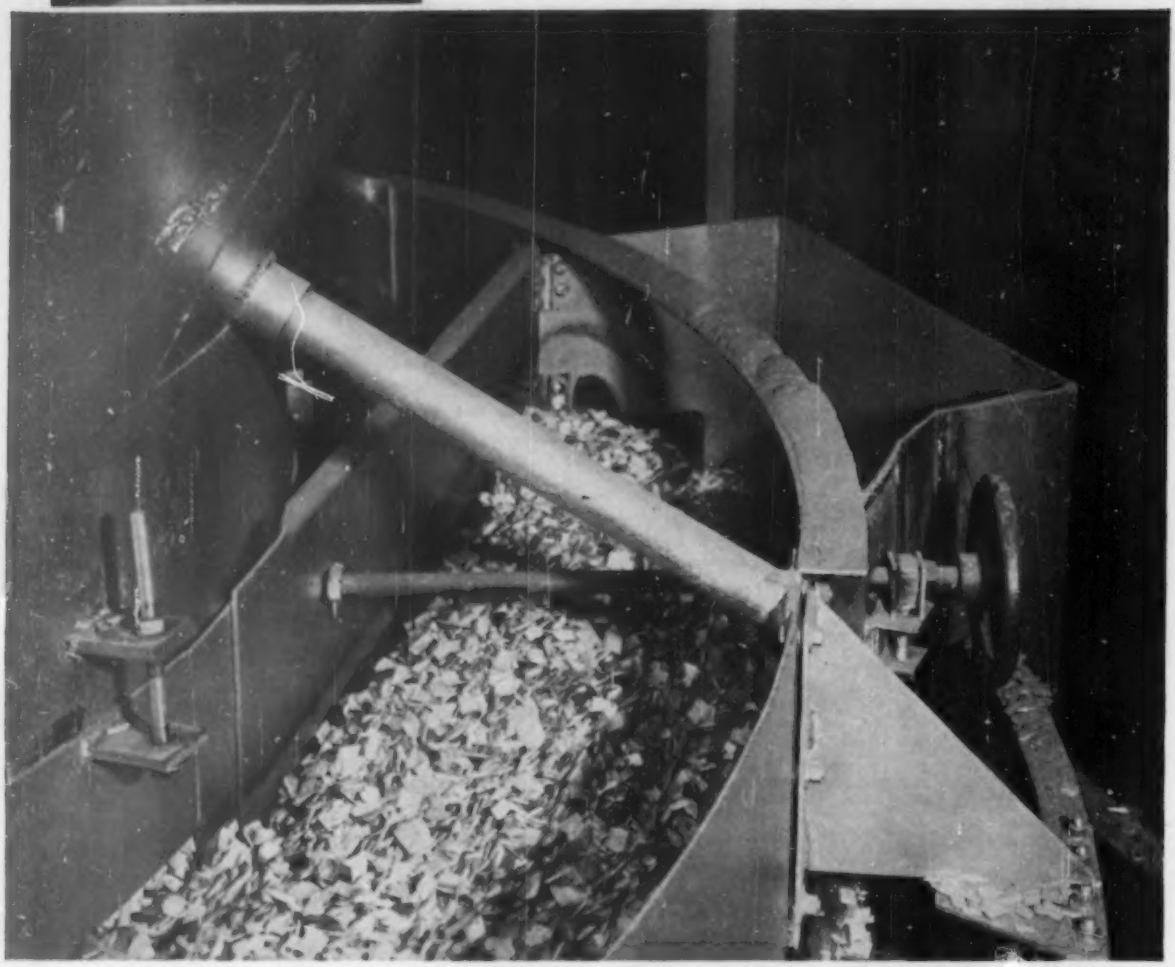
Valley Electric Corporation ... 234
Veeder-Root, Inc. ... 82
Victor Mfg. & Gasket Co. ... 204
Vlier Engineering Corporation ... 98

Wagner Electric Corporation ... 106
Waldron-Hartig, A Division of Midland-Ross Corporation ... 218
Warner Electric Brake & Clutch Co. ... 79
Waukesha Foundry Co. ... 185
Webster Electric, Oil Hydraulics Division 91
White, S. S., Industrial Division ... 208
Winsmith, Inc. ... 76

Youngstown Sheet and Tube Co., The ... 38, 39

Engineers Available or Wanted ... 246

Jeffrey devises metered flow system for Celotex



Wood chips, fed into the giant silos (above), are metered into the process system by Jeffrey 12-foot rotary table feeders.

A method for metering a constant flow of wood chips from storage silos into the production stream was needed at the L'Anse, Michigan, plant of Celotex Corporation. Specifications required the control device also be capable of adjusting to variant wood chip flow requirements. To resolve the situation, Plant Engineers Giffels and Rossetti Inc., worked in close harmony with the Jeffrey General Engineering Department.

Celotex's problem has been solved by twin wood chip storage silos. At the base of each is a 12-foot rotary table feeder. Each feeder, operating at 3 rpm, has a capacity of 5400 cubic feet, or 67.5 tons of wood chips per hour.

More and more progressive industries are turning to Jeffrey for experienced assistance in automating conveying and processing operations. For specific information regarding your requirements, write The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.

Conveying • Processing • Mining Equipment... Transmission Machinery... Contract Manufacturing

JEFFREY

Circle 391 on Page 19

and here's how Pheoll solved it

He's skimming the surface now—yet a short time ago this design engineer was "knee-deep" in a 2-way fastener problem: First, how to hold a board absolutely rigid against the flange guide of a table saw; and second, how to produce the fastener on a simplified and economical basis. Originally, his company tried using an ordinary "C" clamp, but later switched to a hand-assembled 3-piece post clamp. This too proved costly and inadequate.

Pheoll came into the picture and immediately reduced material costs and eliminated a bending operation; replacing a four slide part with a cold headed thumb screw. Then Pheoll dog-pointed and end-drilled the bottom of the thumb screw which allowed the attachment of a permanent spinning grip washer. Previously, this piece consisted of three parts manufactured by three separate industries.

Pheoll automatically produced and assembled the one-piece unit, shipping it to the table saw manufacturer at lower costs—with none of the previous manufacturing, assembly or inventory problems. *This is Pheoll in action*—a versatile, cost-conscious, quality-minded team ready to serve you...the next time you have a fastener problem.

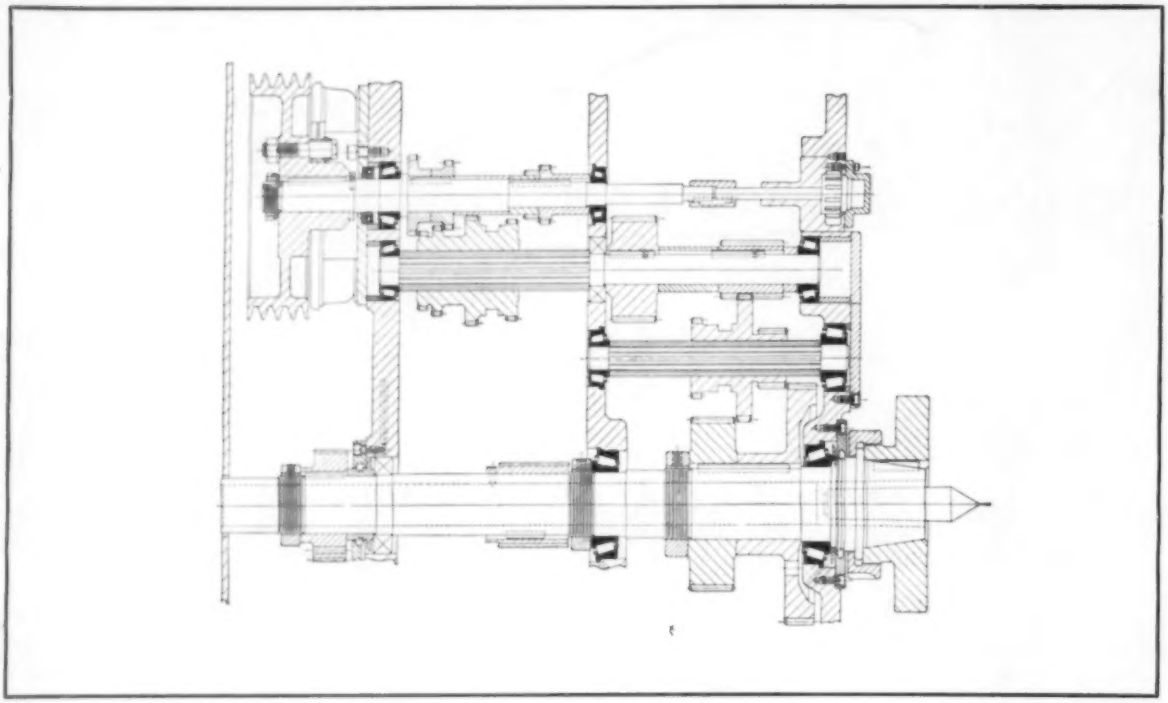
HEADING THE FASTENER INDUSTRY FOR OVER 50 YEARS

Pheoll Manufacturing Company, Inc.

5700 WEST ROOSEVELT ROAD CHICAGO 50, ILLINOIS

Circle 202 on Page 19

LeBLOND lathe obtains super spindle-runout of less than .000025″ with Timken® "00" bearings



To raise the already great precision of its 15″ Dual-Drive lathe to a special new high for a customer, LeBlond had to meet this requirement: spherocity of the part to be turned—a beryllium gyro float assembly—had to be concentric with its two major axes within .0005″ total indicated runout. Diameter of the sphere: 1.8750″.

To assure this, LeBlond engineers specified Timken® super-precision "00" tapered roller bearings held to .000025″ assembled runout for the spindle—one-third the normal runout tolerance for these bearings. Timken bearings were also used on the intermediate, back and feed shafts of the drive. The assembled spindle runout (total indicator reading) was actually less than .000025″.

Producing super-precision bearings like this is typical of Timken Company service. The kind of service that developed Timken "00" bearings to meet industry's needs for ever-greater precision. It's another example of the Timken Company's leadership in tapered roller bearing design and manufacture.

YOUR BEARING PROBLEMS can often be solved on-the-spot by our graduate engineer salesmen. Working with you at the design stage, they can help you select the Timken bearing to meet your special needs, save you time and money.

Industry rolls on

TIMKEN®

tapered roller bearings

The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO." *Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.* Canadian Division: Canadian Timken, St. Thomas, Ont.

Circle 203 on Page 19